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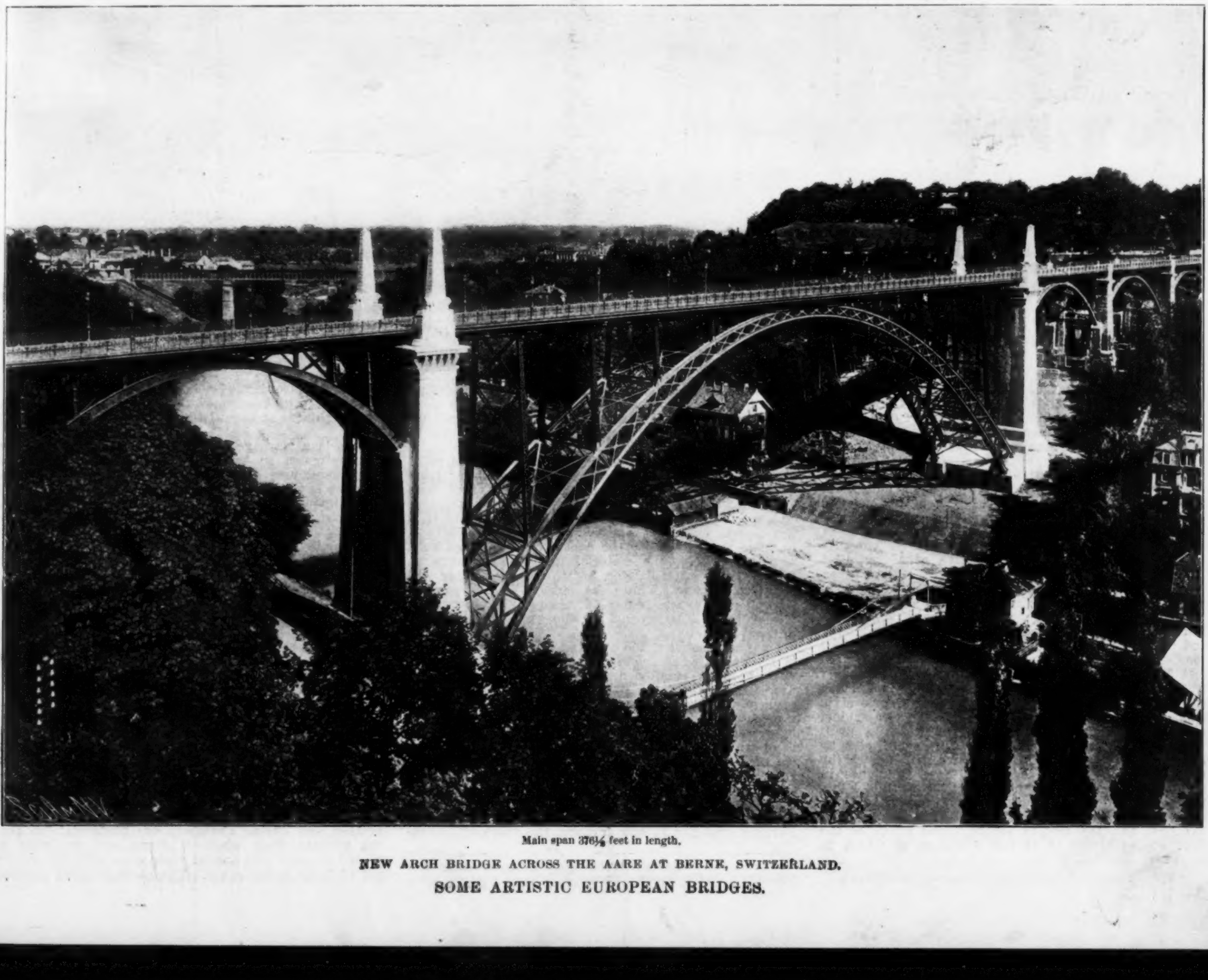
Main span 616½ feet long; two side spans each 113 feet long.

THE BEAUTIFUL STEEL BRIDGE AT BONN, WITH PIERS DESIGNED TO MATCH THE MEDIEVAL CASTLES OF THE RHINE.



Main span 376½ feet in length.

NEW ARCH BRIDGE ACROSS THE AARE AT BERNE, SWITZERLAND.

SOME ARTISTIC EUROPEAN BRIDGES.

SOME MODERN TYPES OF SWISS AND GERMAN BRIDGES.*

THE unquestionable grace and beauty of the bridges recently erected by engineers on the Continent of Europe are acknowledged the world over. While it is true that, in securing the good architectural effects which mark these bridges, there has been a slight sacrifice of some of the principles of good engineering practice, as we understand it in this country, it cannot be denied that, on the whole, the compromise has been a wise one, and the result harmonious and pleasing.

We present some excellent views of a few notable bridges that have been erected recently in Germany and Switzerland. One of the most beautiful of these, both in itself and because of the exquisite natural surroundings, is that known as the Kornhausbrucke, over the River Aare, at Berne, Switzerland. The structure consists of one main span across the river, with a series of smaller spans, which carry the roadway to the abutments on each side of the valley. The main span, which is of trussed steel arch construction, measures 376½ feet between skewbacks. Of the seven smaller spans, five measure 113 feet between skewbacks, and the other two 51 feet. The total weight of steel in the main span is 905 tons, while the weight of all the side spans is 915 tons. The floor of the bridge, which is supported upon the crown of the arches and upon steel bents extending from the arches to the floorway, provides for a driveway 23.5 feet in width, and two footways for foot passengers 8.8 feet in width, making a total width of floorway of 41.3 feet. The treatment of the stone piers is pleasing, and conforms well with the steel structure, although we think that the small obelisks flanking the main piers look somewhat insignificant and might well have been omitted.

The three-span bridge over the North Elbe, at Hamburg, is an odd but unquestionably graceful structure. It consists of three, double, bowstring trusses, each of 325 feet span, each truss consisting of an upper and lower truss with tension members connecting them at the panel points, the floorway being supported directly from the lower chord of the lower truss. A notable instance of this type is to be found at Pittsburg. The bridge, as we have said, is a somewhat graceful structure, although we think it scarcely compares, in this respect, with the more common type of bowstring truss with a straight bottom chord. A curious effect is produced in the present instance by the fact that the upper and lower members are struck to such a radius that they produce a series of reversed curves, with the unfortunate result that an effect is produced that is strongly suggestive of a magnified Coney Island switchback. The medieval design given to the abutments of the bridge provides a dignified and worthy gateway to this important structure.

The Düsseldorf Bridge, and that built across the Rhine at Bonn, were designed by the same engineer, and constructed at the same steel works. The former consists of two main spans across the river, each 393 feet 9 inches in length, and rising to a height of 77 feet above the roadway. Each end pier is finished with a massive portal, built in the Renaissance style from designs by Prof. Schill, of the Düsseldorf Academy of Art, for the design of which a prize was awarded him. The plans of the bridge were by Prof. Krohn. It consists of a short span across the roadway at the river's edge, 196 feet 10 inches in length, followed by two main arches; while the approach on the other side of the river consists of three shorter spans, which are respectively 206 feet 8 inches, 187 feet, and 164 feet in length. The width of the floor of the bridge is 46 feet 6 inches, of which 26 feet 10 inches is given up to the driveway, and about 20 feet to the use of pedestrians. The total weight of the steel work in the bridge is 1,760 tons. As will be seen from our engraving, the main spans consist each of a pair of steel trusses, the roadway being suspended from them by vertical ties, attached at the panel points.

The new Bonn Bridge, over the Rhine, is of the same type and surpasses the Düsseldorf structure in beauty. It consists of a main span 616.4 feet between skewbacks, which rises to a height of 150 feet above low-water mark. The upper chord lies entirely above the floor of the bridge, while the lower chord intersects the floor at a distance of 52½ feet from the piers, and rests upon skewbacks formed on the piers below the roadway. The approach to the main arch is by two smaller arches, each 113 feet in length. The floor of the bridge has a clear width of 23 feet between the trusses, while on the outside of the trusses are two footways, each 11½ feet in width. The city of Bonn, when deciding to build this structure, determined that the bridge should constitute a gateway that should be monumental in character and characteristic of the historic Rhine, which it crosses. To this end, the two main piers were built in the form of tower-flanked castle gates, each with a central passageway and two side parapets. The architectural features were made to conform closely to those of the medieval castles on the Rhine, and if we bear in mind the location and surroundings of this bridge, we must admit it is one of the most successful, judged from an artistic standpoint, to be found anywhere in the world.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

Two main spans each 393 feet 9 inches in length.

THE DÜSSELDORF BRIDGE ACROSS THE RHINE.

SOME ARTISTIC EUROPEAN BRIDGES.

[Concluded from SUPPLEMENT No. 1428, page 22887.]

AN INVESTIGATION OF A GARBAGE CREMATORY.*

OUR observations show that much of the water which is brought with the garbage and settles to the bottom of the carts, percolates through the drying grate into the evaporating pan, which was quite filled with perhaps half a ton of water. To evaporate all these drippings would require a considerable amount of heat.

It is clearly more economical from a calorific point of view, to prevent this large amount of water from getting into the furnace, than to let it first pass through what is supposed to be the drying chamber and then into the sewer. It is quite proper, and it is the custom in many places, particularly in Europe, to dump the garbage on the floor around the feed hole, not only to mix the material properly for burning, as will be mentioned later, but to let what water will drain off go directly into the sewer. The economical as well as beneficial effect of this prior draining during at least a large part of the year will be quite noticeable.

I am satisfied that the calorific value of this garbage is such that its complete combustion could be secured with a much smaller amount of coal than is now used. To obtain this result, it will be necessary to operate the crematory along the lines already mentioned with a view of preventing a nuisance, and to have a furnace in which the combustion of the garbage can be more economically obtained, i. e., to insure complete combustion without excessive loss of heat. It remains, therefore, to examine into the essential parts of:

2. The Garbage Furnace.—Although the nature and composition of garbage affect greatly the relative burning qualities in any furnace, the successful burning in any case will depend primarily upon the construction of the furnace itself. Garbage furnaces in England, where they have been used for half a century, are usually divided into small units called cells, in a manner similar to a battery of boilers, and are arranged in pairs straddling a common main flue. Each cell has a separate connection with this flue and is operated independently of the other cells. The grate area of one cell is usually 25 square feet, this being the size which has been found to be most conveniently and economically operated. The grate bars are usually detachable and have an effective air space of about 25 to 30 per cent of the grate area. They are usually inclined to the front so that the garbage from the feeding hopper can slide down or be raked down upon them. The chamber over the grates is of ample size, longer than the grates, and slopes with the grate surface. Over the upper end of this incline is the hopper and opening for receiving the garbage. As it burns away on the grate below, the raw material above slowly slides down to take the place of the consumed material. While descending, it is subjected to the influence of the heat from the fire in front and gradually dried and then automatically ignited. The stoker observes the process and aids it by properly pulling and spreading fresh material at the rear and drawing out the hard clinkers and ashes in front.

The gases and hot air pass into flues usually above the grates, and then into a settling chamber where the dust particles deposit. Then they again enter the main flue and pass through the chimney. Generally the gases also pass through a so-called fume-cremator, where they are reduced to an inodorous condition. In some European refuse destructors, as they are called, the heat of these gases from the main flue is utilized in making steam for power or electric lighting. To aid combustion forced draft is frequently resorted to, either by steam jet or air jet, the jet entering under the grates of the furnace. It is found greatly to increase the burning. Dampers are placed on the main flues and on the flues connected with each cell. The latter are always closed during the process of firing, raking, or cleaning of a cell. Ash pits and cleaning doors are provided under the gates of each cell, also cleaning doors at the settling chamber, flues and chimney.

American garbage furnaces differ essentially from the European in that the grate surfaces are much larger and practically horizontal. The result of this practice is that when wet garbage is dumped here and there upon the burning garbage, the fire is suddenly and partially extinguished below. A very irregular burning is caused thereby which it is necessary to improve by the addition of coal. It also requires more skillful stoking and spreading of the heterogeneous material over the large horizontal grate and a more difficult operation in removing the clinkers, than in a furnace with a sloping chute and a grate of much smaller area, on which the material is gradually brought from a moist state to one of great heat, resembling a self-feeding coal furnace.

The amount of garbage burned in each English cell will depend upon its composition and moisture. With proper drying it is usual in Europe to burn 5 to 7 tons per day per cell of 25 square feet of grate area. In the Berlin Experiment Station something less than 6 tons were burned, and owing to the small amount of combustible material in the Berlin garbage it was necessary to add some coal during certain seasons.

Considering the furnaces operated in your city, in the light of the above remarks, the nature of their defects seems to me apparent. The grates of both combustion and drying chambers are horizontal, so that the garbage stays where it drops, and can only be moved forward and spread with some difficulty by the aid of large heavy rakes. The garbage when dumped

* Extracts from a report by Rudolph Hering to the Special Committee on Crematory of the City Council of Trenton, N. J.

into the drying chamber is formed into a dense heavy pile, only the upper portion of which is usually raked down upon the combustion grates, leaving the lower portion undisturbed and unburned often until the last of the garbage is consumed at night. This raking down of the upper portion does not insure us that the garbage will be completely burned. Even pulling it down upon the coal fire in front does not do this, unless much more time and skill are used than were observed during our examination.

The amount of garbage burned in Trenton per equivalent of English cell area (see Table II.) is as much as about 14 tons, considering only the coal grate surface in the combustion chamber, while in Europe the quantity ranges from six to seven tons. It must be realized, however, that in Trenton much burning takes place in the first or dry chamber. All of the highly combustible materials, as paper, wood, straw, and the like, are there consumed and should not be credited to the second or combustion chamber. Although in Trenton, to aid combustion, about 120 pounds of coal are used per ton of garbage, in Europe the unused coal in the ashes of the mixed garbage amounts roughly speaking, to the same quantity.

The analysis in Table I. indicates that, leaving out the ashes with its unburned coal, the net burning quality of European and American garbage is not very different. This evidence, although it is meager, indicates that you cannot maintain a higher rate of combustion per square foot of grate area than is maintained in the furnaces abroad. Independently of the material burned over the grate of the drying chamber, which I think we might estimate as being at least one-fourth of the total amount, we still have a greater amount of garbage proportionally per square foot of grate surface passing through the combustion chamber than is found to be practicable in the best furnaces abroad. From this reasoning we may infer that the combustion in Trenton is not as thorough as in England, and such inference seems to agree with the facts as found. Remedies for this defect of insufficient combustion in the furnace can be obtained: 1. By increasing the number of furnaces. 2. By running the crematory for twenty-four hours. 3. By improving the burning capacity of the furnace.

To increase the number of furnaces is a matter that will need attention in any event at no distant day. By building another furnace at once, the present overcharge could be relieved. Whether an additional furnace had best be built at the present site or in another part of the city, where it might decrease the length of haul for collection for some districts, while increasing the unit cost of labor for attendance, I did not ascertain. Should it be found impracticable to build another furnace at present, it is entirely practicable to run the present crematory for twenty-four hours, by using two or probably three shifts.

Continuous operation has merits, in a more uniform service and in a saving of the losses of heat due to cooling and to the starting of fires every day. At present you are frequently obliged to run during a portion of the night, and the additional cost of running continuously would not be proportionately greater. Continuous operation requires storage of the garbage for use during the hours when no collections are made. Should all garbage be collected in 12 hours and burned at a rate to consume it in 24 hours, storage must be provided for one-half a day's supply. This at present would be about 15 tons, requiring about 25 cubic yards of storage. If piled 2 feet high this requires a space less than 20 feet square, for which there is ample room.

Referring to what has been said regarding the preliminary draining of the garbage and what will yet be said regarding the feeding to the fires, this storage on the feeding floor is an advantage to be recommended to you also for day service, whenever the state of the fires and an unfavorable previous charge makes temporary storage of some of the garbage necessary in order to obtain better combustion. The temporary storage of this material for a few hours cannot cause any nuisance if it is freshly collected. Such storage is customary in Europe under similar conditions.

While the continuous operation of the furnaces can relieve some of the present difficulties, the third mentioned remedy, namely, the improvement of certain parts of the furnaces, should be likewise recommended. An improvement which I believe to be of much practical value in securing complete combustion without excessive loss of heat, is the introduction of the sloping grate, and of a drying chamber having **a floor sloping toward this grate at a different angle to feed, if not automatically, yet with only slight aid** from the stoker. By this means the garbage passes gradually from its natural state to that of complete combustion, and the difficulties of stoking are reduced to a minimum. The hottest fire will be near the front of the furnace, and here the fumes get their most effective burning.

The gases should therefore leave the furnace near the front. They should pass to the rear outside, but closely to the walls of the drying chamber, and in such a manner that these are heated as much as practicable, and thus help the drying process from the bottom, sides, and rear of the chamber, as direct radiation from the hottest fire helps it in front.

Should the garbage be well drained on the feeding floor, the drying chamber would need no grate or evaporating pan.

Regarding the introduction of forced draft by blowers forcing air under the grates, it may be said that the advantage of this assistance is recognized in Europe and utilized in the best furnaces. I have no hesitation in expressing the belief that an improvement in the design and operation of your furnaces, with a greater air pressure below the grate, could enable steam to be made in sufficient quantity to operate such blowers, but also, as may be inferred from what has been said above, accomplish the burning with better effect as regards the escape of unburned particles than the aspiration from a more rapid chimney draft, drawing up the fumes from the upper surface of a mass of burning garbage.

Under the present heading it yet remains to speak of the auxiliary fires burning between the furnace and the chimney. Without question such fires are needed at times when for one reason or another it is advisable separately to cremate the fumes coming from the furnace before they ascend the chimney. In your case this may always be required, because the location of the crematory is near the built-up parts of the city, and because the difficulty in training men to operate such a plant properly always points to the wisdom of having a safeguard against slight imperfections of manipulation. Such auxiliary fires must, however, also be carefully run to secure the object for which they are kept burning, and at any time proof of this should be readily obtainable by inspection.

3. The Operation of the Furnace.—Almost, if not equally as important as the proper design of a furnace, is its skillful operation, and too little attention has usually been given in our country to this feature of garbage destruction. A little indifference or carelessness even with the best furnace can result in incomplete combustion, with the resulting annoyance above described. It is a simple matter to burn a homogeneous material, such as coal or wood, but to operate a furnace with probably the most complex mass of matter apt to be found in a modern community, is difficult and also serious from the deleterious effects resulting from failures. The employment of specially trained firemen having good judgment, attentive, and faithful, seems to determine the success or failure of the undertaking.

Good judgment with regard to the conditions and time of firing and feeding of garbage and with regard to the selection of material for succeeding charges so as to maintain the necessary heat, close attention to all of the dampers for regulating the drafts either when feeding, stoking or cleaning, scrupulous care in seeing that no unburned particles are removed with the ashes, are all simple matters, though when they fail even singly they may give imperfect results, and failing together they may be disastrous.

When the garbage is delivered at the crematory too rapidly, or not in the best order for firing, as already mentioned, it should be stored. The storage may be in the carts themselves, or on the floor near the feeding holes, as done without annoyance in nearly all crematories abroad. When a load of paper, wood, and rubbish arrives, it should not, as was observed on one of our visits, be charged on top of a load of fresh garbage, but be dumped to one side and fed at a time when its fuel value for the moist material will be more effective. This heat value of the dry rubbish is quite appreciable, and in one instance was estimated roughly at one-third the value of a ton of coal, without being utilized for the burning of any fresh kitchen garbage.

The temporary storage of the garbage on the floor over the furnaces, for a better mixing and drying of the same, requires suitable gutters to be formed on it which will collect the water and carry it to the sewer.

Careful attention must also be given to the auxiliary fires, so that they burn briskly at times when the conditions for the escape of odorous fumes from the furnace are most favorable.

All ash pits, flues, dust chambers, and other parts of the furnace must be frequently inspected and cleaned, since any deposits may contract the sectional area of the flue and thereby modify the normal draft through them.

Résumé and Recommendations.—It now remains briefly to summarize the foregoing into a statement of the annoyances you are experiencing, with recommendations of the most efficient practical means of removing them. Notwithstanding the existing defects and criticisms which it has been necessary to make, the Trenton furnaces belong to the better class of such plants in our country. The trouble and nuisances with which you are now contending are also more or less common elsewhere.

The chief reason for this fact appears to be the insufficient attention that has been given the subject by those able to do so. Sufficient inquiries have not been made into all the various causes of the specific troubles, so as to correct each and all of them in an intelligent manner. In many quarters there appears to be even a lack of appreciation of the real difficulties involved in the problem, both as regards construction and operation. Especially as to the latter there is a disposition to undervalue the necessity of having operators with a good practical knowledge of firing such complex material as garbage, so as to obtain complete combustion, of the effects and interaction of drafts in furnaces operated separately, but leading into the same main flue, and of the means for settling the dust which rises with the fumes. As soon as these difficulties are more generally appreciated, their proper solutions will no doubt soon follow.

The character of the Trenton garbage collection is at present fairly satisfactory. The best practice in this climate regarding the receptacles at the house suggests galvanized iron buckets with cover. These become less foul than if made of wood, and the covers prevent the scattering of the material by animals or wind and the dissemination of filth by flies. The collection in well-constructed metal carts such as you have and also the frequency of your collections are quite satisfactory. It may be suggested, however, that provision for thorough cleaning of the carts after dumping would be a still further improvement. To obviate the escape of odors from ashes that have not been completely burned, it is necessary to have furnaces that will economically burn the garbage, and also very attentive as well as skillful firemen, trained and experienced in this special kind of work.

To obviate the nuisances of dust escaping at the stack, either from well burned or unburned garbage, it is necessary after securing perfect combustion, to introduce a dust-settling chamber of proper size between the furnaces and the stack, containing baffles and properly placed inlets and outlets. The screens now in the chimney, although useful as a safeguard against accidental emissions of light but large matter, are insufficient to retain all of the matter now escaping from the furnaces.

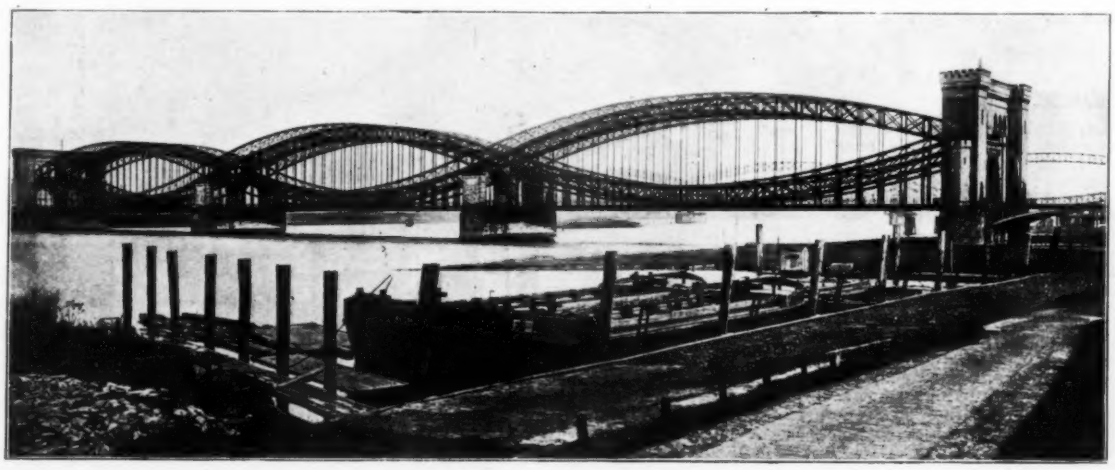
To reduce further the possibility of unburned particles escaping through the stack, it is important to place dampers in the flues leading from each furnace, as well as in the chimney, so as to afford control of the drafts at all points where and when it is needed. Skillful observation at every moment of the condition and character of the garbage, and faithful attendance in operating the dampers to maintain an effective velocity of the gases, which at the same time does not carry the dust, are necessary to obtain success.

The prevention of odors due to unburned gases escaping from the stack depends upon the character of the garbage, the sufficient capacity of the furnace, its design and the operation of the plant.

The garbage now delivered, when properly drained and carefully burned in a well designed furnace, is readily combustible, and should not require the addition of as much coal as now used; and at some seasons, except to start fires and otherwise on rare occasions, perhaps no coal may be required.

We find that the furnaces are not sufficient in size to effect a complete destruction of the material during the hours of the day when the crematory is operated. Continuous firing for twenty-four hours can relieve this deficiency. To this end it would be necessary to store the material for a part of the day, and this could not be objectionable in any way.

To secure a complete combustion of the garbage more economically than at present, the design of the furnaces should be somewhat altered. **The horizontal grates are not the most suitable for the material,**



Each of the main spans is 325 feet in length.

THE NORTH ELBE BRIDGE, HAMBURG.

SOME TYPES OF EUROPEAN BRIDGES.

which must first be dried and then with difficulty pulled from one position to another for burning. A sloping grate for burning and a sloping floor for the drying chamber, from which the material can be gradually and almost automatically moved from the feed holes to the hottest fire, permit of a better utilization of the heat and reduce the difficulties of stoking.

The gases should leave the furnace from a point above the hottest fire, and be utilized to heat the walls of the drying chamber so as to assist in the proper preparation of the garbage for burning. Forced draft under the grate will also be of great advantage in aiding combustion.

Auxiliary fires for burning the fumes before they rise into the chimney are a wise addition to your crematory, and should be retained as a safeguard on account of nearness to the inhabited parts of the town.

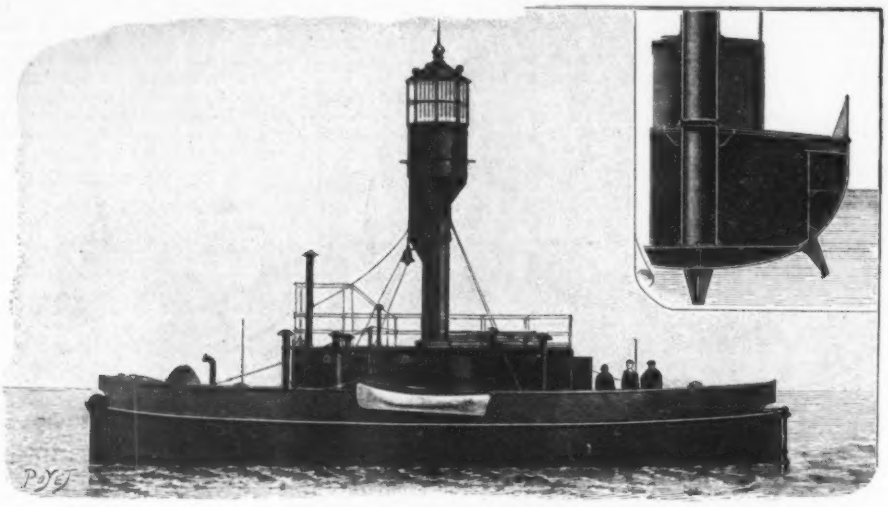


FIG. 1.—THE TALAIS LIGHTSHIP.

THE NEW LIGHTSHIPS OF THE COAST OF FRANCE.

FOR several years past, Engineer-in-Chief Ribiere, of the Lighthouse Service, has been constantly occupied with the question of transforming and improving the lightships of the coast of France. For this purpose it became necessary at the outset to modify the lighting apparatus, which, with their reflectors, were incapable of giving more than 1,500 carcels, and, from this point of view, advantage was derived from the experiments that had been made with a view to the use of compressed air and incandescence in ordinary lighthouses. It became necessary, moreover, to make considerable changes in the boats themselves. The conclusion was reached that the nature of storm-waves, which alone are capable of affecting the stability of such boats, can be perfectly defined, the duration of their oscillation being nearly constant at every point; and, since we know also their direction and that of the boat in the various states of the tide and current, it is possible to apply to the boat the theory of oscillating bodies.

The first series of lightships have been constructed in recent years. They are the new "Dyck," the new "Ruytingen," and the lightship of Talais. The moment of transverse inertia of these has been increased by a proper distribution of the ballast, which has been arranged as far away as possible from the center of gravity. Moreover, the diminution of the rolling motions has been assured by lateral keels having considerable of a projection. We must say that as regards the two first lightships that we have mentioned, the solution of the question was imperfect, and, upon the whole, very costly, since the new "Ruytingen," for example, necessitated an annual expenditure of $8,000, while the luminous power furnished was no more than 1,200 carcels. It therefore became necessary to think of smaller vessels, in which, moreover, gas should be utilized for the lighting. An experiment was made in the first place with a boat designed to operate without a keeper near the plateau of Rochebonne. This new vessel is 47.5 feet in length, 21.75 feet in breadth, and 8.8 feet in depth. It carried at the summit of a tubular mast, at 33 feet above the water, a lenticular fixed-light apparatus supplied with compressed oil-gas. But, since its motions were too heavy, and a habitable boat carrying a flashing incandescent gas-light was desired, the Talais lightship was built. This boat is 50.5 feet in length and 19.5 in breadth, and its mast carries an incandescent flash light. It is provided with three keels, each of which is 30 inches in height. The rolling is almost null, owing to the distribution of the weight, and, although the pitching is very sensible, the vessel affords comfortable quarters for the three men that compose the crew. Up to this time, merely the transverse stability had been considered. From the standpoint of general stability, there was to be had the example of luminous buoys, which preserve their absolute verticality in almost all kinds of weather, because their float is prolonged beneath by a ballasted tube, which lowers the center of gravity beneath the center of the float. But the adoption, for lightships, of such a form, which is incompatible with the facilities of maneuvering and the navigability required by certain of these vessels, could not be thought of. What was required, in fact, was a sort of ship, but one that presented a feeble loadwater-line surface and a center of gravity placed as low as possible.

It was in order to respond to such desiderata that the "Snouw" was constructed and afterward anchored near Dunkirk, where the draught of the other boats has been increased by 4 feet and the ballast formed of pieces of cast iron secured to the central keel, externally to the vessel. Moreover, the extremities of the vessel have been made sharper. The length is 65.6 feet, the breadth 9.6 feet, the depth 13 feet, and the draught 11.75. The resistance of this boat to rolling is nearly absolute; but, in following up and emphasizing this character, there has been created a pitching proper to relatively long periods, and which is capable of giving a total amplitude of 45 deg. in case of a synchronism with a wave. It has been found possible to reduce such pitching by applying wooden sheathing to the front and rear of the boat. Let us add that a fixed light has been substituted for a flash one, and that this considerably diminishes the weight placed at the top of the mast. Finally, these successive experiments have led to a type which cannot as yet be fully judged of, but according to which two new boats have been constructed: The "Sandettie," which was launched some time ago, and the "Dunkerque," which has but recently been set afloat, and which is built exactly after the same plan. We shall be content to give a brief description of the "Sandettie." This vessel, which is 114.8 feet in length 20.5 feet in width, and 16.75 feet in depth, presents a very characteristic keel arrangement, especially in transverse section. Its draught is 15 feet, and the height of its keels in the center 32 inches. Its arrangements comprise all the installations of a first-class lightship; sonorous signal operated by steam compressors, steam or air windlass, and gas lantern emitting flashes every five seconds. The crew consists of a captain and eight men. We shall not dwell upon the lines of the boat, since these are shown sufficiently well in the accompanying Fig. 2. As regards the optical part, we shall merely remark that the old arrangement, in which the reflectors were carried by ordinary gimbal joints and were capable of making considerable angles with the vertical, have been discarded, since such a combination would have been impossible with the very condensed pencils of light of the lenticular apparatus. Recourse has therefore been had to a sort of compound pendulum, the lenticular lantern of four panels being prolonged beneath by a rod which carries a lead counterpoise. This rod is fixed by a gimbal joint placed beneath the apparatus in the center of a horizontal circle moved by the rotary apparatus of the lantern and rolling upon steel balls. At the summit of the apparatus, there is a lead counterpoise. The difference between the duration of a simple oscillation of the apparatus and that of a half-period of rolling motion is such that the deviations of the apparatus do not exceed from 5 deg. to 6 deg., and thus can have no prejudicial effect on the lighting. Moreover, the two axes of the gimbal joints consist of steel knife-edges resting upon fulcrums of the same metal, thus assuring the pendulum an extreme liberty of motion.

The apparatus is illuminated by incandescence through compressed oil-gas. A revolving ajutage and a rubber tube permit the gas to enter in a proper manner. The luminous power of the light is 3,500 carcels.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

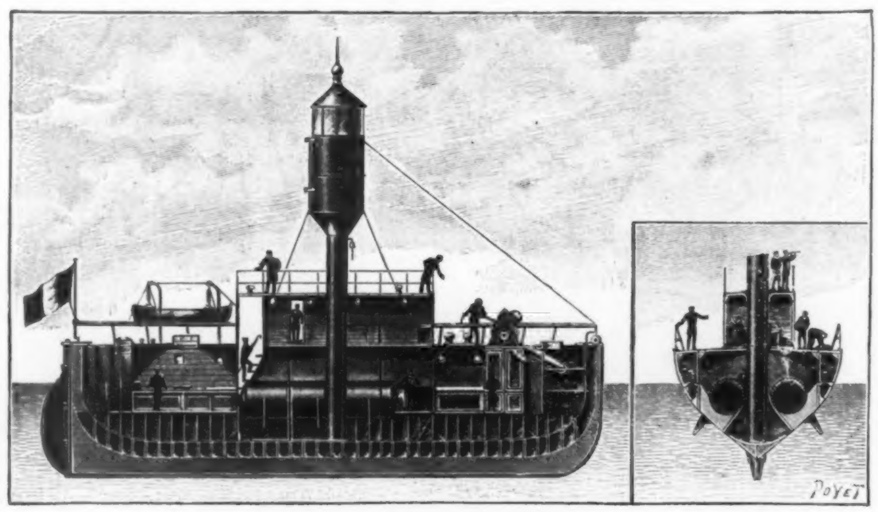


FIG. 3.—THE "SNOUW."

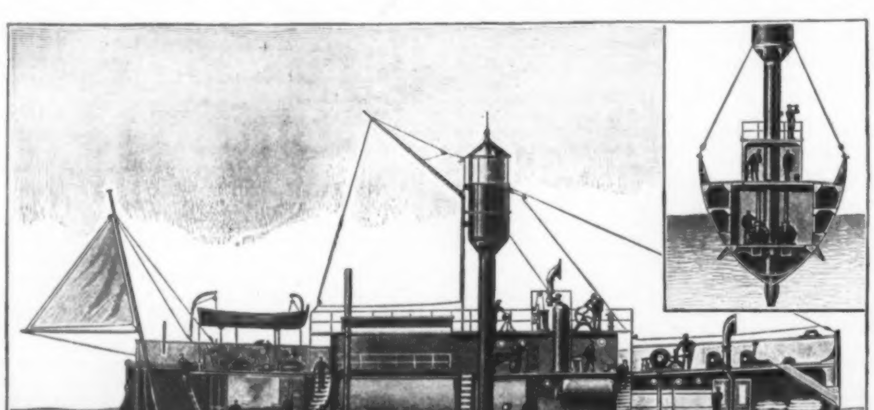


FIG. 2.—THE "SANDETTIE" AND "DUNKERQUE."

AN ANCIENT CAMP.

WHILE making an excavation for the abutments and wingwalls for a bridge that is being built over Clarks Creek at Skiddy, J. A. Johnson unearthed a prehistoric camp. Mr. Johnson discovered the camp after scraping away the ground to the depth of about eight feet. He found an ancient fireplace built of stone and scattered about this were charcoal, buffalo bones, arrowheads, and many other articles that indicate that a primitive people were encamped there at one time. A small bronze coin about the size of a dime was found but no date is discernible on its face. It is thought to be a Spanish coin. Trees that are estimated to be hundreds of years old are growing close to the place where the excavation was made.

It is thought by persons living in the vicinity of the bridge that other archæological relics can be found in that neighborhood if a search were made. The finding of the bronze coin also reminds many persons that Coronado once marched into this part of the State in search of the mythological Quivira.

THE SERPOLLET STEAM AUTOMOBILE.

II. THE MOTOR.

THE Serpollet motor consists of a crank case of cast steel, to which are bolted, on opposite sides, two pairs of cylinders. Each pair of cylinders is clamped to the crank case by six nuts that screw on studs projecting from the latter, as shown in Fig. 2. The entire motor is suspended from the chassis by four studs with nuts (*r*, *t*, *s*, *u*, Figs. 1 and 2). Thus it will be seen that in order to detach the motor from the vehicle for any purpose, it is only necessary to disconnect the various pipes attached to it, and, after placing a box or plank under it for support, to remove the four nuts mentioned. The lower half of the crank case is made of sheet steel. It is readily removable, being held in place by a few round-headed screws.

An asbestos gasket makes an oil tight joint, while in the bottom of the case is a drip cock, through which it should be emptied about once in 15 days. The cover of the crank case is formed by a sheet of aluminium, held in place by six screws. A tight joint is made without the use of a gasket. In Fig. 2, *g* is an oil feed pipe, *i* a plug through which additional oil may be introduced into the crank case from time to time, and *j* the opening for a short pipe which conveys into the atmosphere any steam that happens to escape past the pistons.

On general lines, therefore, the Serpollet motor consists exteriorly at least, of a central steel box or case, on the sides of which are attached two opposite pairs of cylinders, while the whole is attached to the vehicle by four studs and nuts.

If we remove the cover and bottom of the crank case, we shall expose to view a part of the mechanism of the motor, as shown in Fig. 1. This consists of two parallel shafts, placed one above the other, and each making the same number of revolutions per minute. The lower one is the crank shaft of the motor, driven directly by the pistons, while the upper is the cam shaft, driven from the crank shaft by the pairs. The cylinder heads are plugs (*x*, Fig. 2) that screw into the ends of the cylinders. The 12 horse power motor cylinders have a bore of 75 mm. (2.952 inches) and a stroke of 90 mm. (3.543 inches). Each pair of cylinders is cast with four horizontal tubes for the valve stems, as shown in Fig. 2.

The valves are of steel, hardened on the seats, which have a diameter of 20 mm. (.787 inch) for the inlet and 22 mm. (.866 inch) for the exhaust valves. The exhaust valves are made slightly larger than the inlet valves in order that there shall never be any compression in the cylinders at the beginning of the admission stroke. On this account it is necessary that the exit of the vapor take place more quickly than the inlet. It will be noticed also, that the exhaust valve (*S*, Fig. 3) has a longer stem than the inlet valve, *T*. The reason for this is that the exhaust valves (3 and 4, Fig. 1) open into common valve boxes, *e*, that connect with the condenser, while the inlet valves have separate valve boxes outside *e*, connected to common steam pipes, *J* and *K*. The valve stems are about 1-20 mm. (.001 inch) smaller than the tubes through which they pass, and they have several oil grooves running the length of their bearing surface. They are held to their seats by springs that bear against collars pinned to the valve stems. The auxiliary valve stems in the crank case are provided with rollers on the ends that bear on the cams (*G*, Fig. 3), and also with a pin that runs in a groove and keeps the stem, *G*, carrying the roller from turning. Two nuts on the end of each, just outside the crank case, serve for setting exactly the time of opening of the valve.

The driving pinion of the motor is seen at one end of the crank shaft at *P*, while on the other end are the gears, *B E*, that drive the cam shaft, and another gear, *D*, that operates the pumps.

One set of cams on the cam shaft serve for opening the valves of the two pairs of cylinders. When one cylinder is working, its opposed cylinder is exhausting, and *vice versa*. The cranks that carry the two pairs of connecting rods are set at an angle of 90 deg., and not 80 deg. apart, as one might expect to see them. Therefore, when one pair of pistons, i. e., one piston and its opposite, are half way down the working and exhaust strokes, respectively, the other pair are just about to commence these same strokes. The reason for this is twofold: First, when the motor stops, it always stops with an inlet valve open, and consequently can always be started again; second, the motor can be easily reversed.

It is only necessary to displace the cam laterally, so that while one cylinder is exhausting, its exhaust valve shall close and the inlet valve open, in order to reverse the motor. This can be done very quickly. In fact, the motor can be reversed several times per second, or as fast as the operator can work the reversing lever, without damaging it in the least.

Fig. 4 shows the eight cams for operating the eight valves of the motor—four for opening these valves for forward movement, and four for the reverse. These cams are squared on the shaft and held between two collars (*i*, *i*, Fig. 3) that are pinned to it with conical pins. They are made of steel, hardened to a depth of 2 mm. (.078 inch), and polished. Therefore they will last a great while in use, especially as the rollers of the auxiliary valve stems only bear upon them.

The cams are necessarily placed upon the cam shaft in the order in which the valves are arranged, viz., the exhaust cams for forward motion, 1 and 7, on the outside, and the inlet valve cams for forward motion, 3 and 5, in the center. Each of these cams has on its right another smaller cam which is used for reversing the engine.

Thus it is that exhaust cams 1 and 7 have beside them the reverse cams, 2 and 8; and inlet cams 3 and 5 have next to them inlet reverse cams, 4 and 6.

Each forward motion cam is separated from its adjoining reverse cam by a smooth place where the valves receive no movement. This is the off, or stop position, which must always be gone through before the reverse is obtained.

The reverse cams are narrower than the forward motion cams, for only the full opening of the valves is used when reversing, while when going forward this is needed only at the start, after which the cut-off may be varied at will, thus increasing the economy in steam. To do this, the cam must be sufficiently wide to allow lateral movement and yet have it stay under the roller of the valve stem. The raised portion of the wide cams narrows toward the right, so that, although the valves are opened always at the same instant, the length of time they are held open decreases. This varies from 85 per cent of the stroke for full admission to 45 per cent of the stroke for the greatest cut-off. All the cams are so that the valves open early by about 15 per cent of the piston stroke, or 2 to 3 per cent early as measured on the circle described by the crank shaft. They remain open always for 85 per cent of the piston stroke after the center has been passed, provided, of course, that the engine is running with full admission.

The sector on the steering port over which the cam shaft controlling lever travels, has four principal notches corresponding to motion ahead, cut-off, stop, and reverse. It can be set in a notch for either of these.

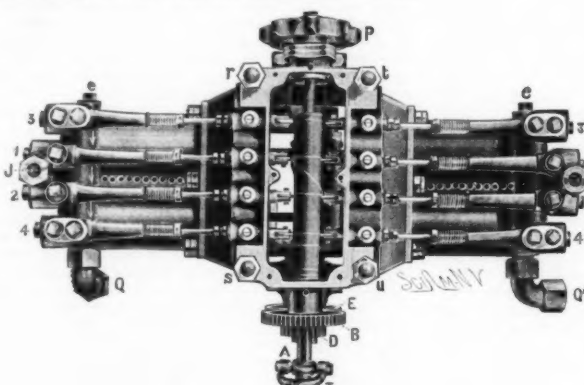


FIG. 1.—PLAN VIEW OF SERPOLLET MOTOR.

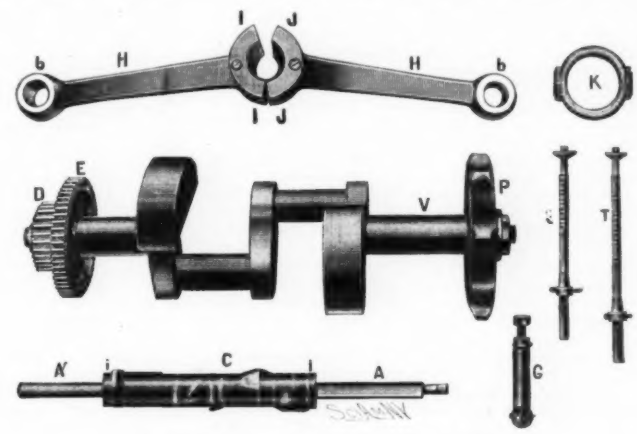


FIG. 3.—PARTS OF SERPOLLET MOTOR.

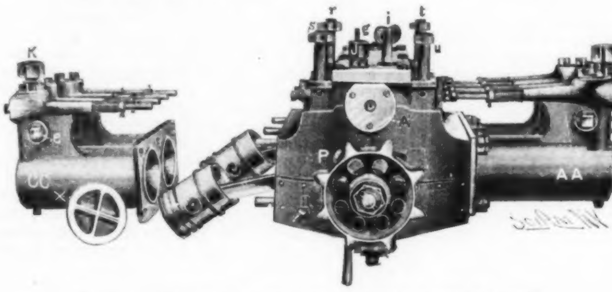


FIG. 2.—SIDE VIEW OF SERPOLLET MOTOR.

FIG. 4.—CAM SHAFT OF SERPOLLET MOTOR.

two gears of the same size, *B*, *E*. The latter is the one that can be seen the best. It is squared on one end, *A* (Fig. 3), and rounded on the other, *A'*; while its mounting in the crank case consists of two bronze rings, one (*A'*, Fig. 3) fastened to the case by three countersunk screws and carrying the round end (*A'*, Fig. 3), and the other, on the side of the case on which are the gear wheels, bushed and carrying a sleeve with a square hole which turns in the ring. On this sleeve is keyed the gear wheel *B*.

By this arrangement, the cam shaft can be moved laterally a certain distance without the gears slipping out of mesh. The eight cams squared on the shaft of course move with it, and by the lateral movement the motor is started, reversed, and the cut-off varied. The shifting fork is seen at *T*, Fig. 1. The crank shaft runs in suitable bronze bearings.

It has a lateral movement of about 2 mm. (.078 inch). The two connecting rods are forged in a single piece and afterward cut apart in such a way that their point of joining forms a V (*I*, *J*, Fig. 3). The bearing is fitted with a bronze box held in place by the two screws shown, which are countersunk and covered with metal. The connecting rods are held in place on the crank shaft by two steel collars, *K*, the two halves of which are fastened together by bolts with suitable lock nuts. The piston ends of the connecting rods are fitted with bronze boxes driven in and screwed in place. The wrist pins are of very hard steel, and are fastened in place and held from moving sideways or turning by a set screw. The lateral play of the connecting rod upon the wrist pin is about 2 mm. (.078 inch), and the longitudinal play, 3 mm. (.011 inch). The pistons are very carefully fitted, as they have to hold pressures far greater than those occurring in a gas engine cylinder. Four piston rings are used, with the joints 90 deg. apart. The rings are pinned, so that they cannot turn.

The cylinders are of cast iron, and are cast in

THE ORIGIN OF BOGS.

IN Knowledge for November, Mr. R. Lloyd Praeger has an article on Bogs, in the course of which we are told that "when our peat-bogs were in their infancy, *Sphagnum* and its associated plants took possession of the ground when marshy growth had proceeded sufficiently far to insure a permanently wet spongy subsoil. Once bog-growth was started, under the favorable climatic conditions which then prevailed, it may have proceeded with great rapidity, the bog-plants checking drainage, storing up water, and spreading ever from their center. In this way the bogs rolled slowly outward from the marshes or springs where they originated, and eventually overwhelmed great areas that had been well-drained land. On the hills, where higher rainfall gave increased facilities, the bogs spread up and down the slopes, enveloping whole mountain ranges in a vegetable covering. The lower layers of our peat-bogs are usually full of the stumps and roots of trees. The whole of the bog sometimes overlies these old forests, which, in such cases, as the roots show, grew on the surface of the clay or gravel which the bog afterward covered. But in most instances the trees are rooted *in* the peat, and sometimes successive layers of tree-stumps show that several epochs of forest-growth occurred during the accumulation of the peat. The distribution of these trees, consisting chiefly of Scotch fir and oak, buried in bogs, deserves special consideration. They are found to extend in Scotland far north of the present limit of the species, while in Ireland, where the Scotch fir is now extinct as a native, the remains of this tree occur in enormous quantity throughout the land. In both countries the old forests appear at elevations in the mountains far beyond the present upper limit of the species. Along the exposed western coast of Scotland and Ireland, enormous stumps may be dug out at various levels where now, even with artificial protection, trees will not grow. Not only that, but in numerous places round our shores, between tides, or even far below low-water mark, tree-bearing peat occurs. So that the evidence of the trees of the lower part of our peat bogs indicates not only a somewhat different climate, which allowed a much wider extension of these forest-growths, but a greater elevation of the land."

[Continued from SUPPLEMENT No. 1428, page 22890.]

ON ELECTRONS.*

By SIR OLIVER LODGE, F. R. S., Vice-President.

PART II.

DISCOVERY OF THE ATOM OF ELECTRICITY.

QUOTING again from the great Treatise of Clerk Maxwell, 1st edition, we find on page 312, in the chapter on electrolysis, the following sentence:

"Suppose, however, that we leap over this difficulty by simply asserting the fact of the constant value of the molecular charge, and that we call this constant molecular charge, for convenience in description, one molecule of electricity."

Thus some idea of the conception of the atomic nature of electricity was forced upon men of genius by the facts of electrolysis and a knowledge of Faraday's laws. But Maxwell went on, after a few more paragraphs:

"It is extremely improbable that when we come to understand the true nature of electrolysis we shall retain in any form the theory of molecular charges, for then we shall have obtained a secure basis on which to form a true theory of electric currents, and so become independent of these provisional theories."

It is rash to predict what may ultimately happen, but the present state of electrical science seems hostile to this latter prediction of Maxwell. The theory of molecular charges looms bigger to-day, and has taken on a definiteness that would have surprised him.

The unit electric charge, the charge of a monad atom in electrolysis, whatever else it is, is a natural unit of electricity, of which we can have multiples, but of which, so far as we know at present, it is impossible to have fractions.

I will extract the following sentence from Section 32 of "Modern Views of Electricity":

"This quantity, the charge of one monad atom, constitutes the smallest known portion of electricity, and is a real natural unit. Obviously this is a most vital fact. This unit, below which nothing is known, has even been styled an 'atom of electricity,' and perhaps the phrase may have some meaning. . . . This natural unit of electricity is exceedingly small, being about the hundred-thousand-millionth part of the ordinary electrostatic unit, or less than the hundred-trillionth of a coulomb."

The atom with its charge is called an ion. The charge considered alone, without its atom, was called by Dr. Johnstone Stoney an electron or natural electrical unit.

What we learn with great accuracy from electrolysis is the ratio of the charge to the mass of substance with which it is associated. It matters nothing how much substance is chosen, whether 100 atoms or one, whether an atom or a gramme or a ton, the amount of electricity associated with it in electrolysis and liberated when the substance is decomposed, increases in the same proportion; the ratio is constant, and if determined for one substance is known for all.

This is the ratio which is technically known as the "electrochemical equivalent" of the substance. In the light of Faraday's laws, if this quantity is measured for one substance it is known for all, because the charge is the same for every kind of atom up to a simple multiple; and hence in specifying electrochemical equivalents there is nothing to consider but the atomic weight or combining proportion of the substance. Thus the electrochemical equivalent of oxygen is 8 times that of hydrogen, that of zinc is 32½ times, and that of silver 108 times that of hydrogen. The substance chosen for a determination of the electrochemical equivalent may be the one which can be most accurately experimented on, and Lord Rayleigh has shown that such a substance is nitrate of silver, and has ascertained that if a current of one ampere is passed from a silver anode to a platinum cathode through a nitrate of silver solution, the cathode gains in weight by 4.025 grammes every hour. Hence the electrochemical equivalent of silver is

$$\frac{4.025 \text{ grammes}}{1 \text{ ampere-hour}};$$

the electrochemical equivalent of hydrogen, being 1-108 of this quantity, is—

$$\frac{4.025 \text{ grammes}}{108 \text{ ampere-hours}} = \frac{4.025}{108 \times 360} \text{ c. g. s.} = .0001035 \text{ c. g. s.} = \frac{1}{96600} \text{ grammes per coulomb.}$$

Hence the ratio of an atom of electricity to an atom of hydrogen is 9,660 $\mu^{-½}$ c. g. s units, or approximately

$$10^4 \sqrt{\left(\frac{\text{centimeters}}{\mu \text{ grammes}}\right)}$$

the unknown constant μ necessarily making its appearance because we are comparing quantities measured in different ways, viz., electricity and matter.

The numerical part of this quantity is known with comparative exactitude,† that is to say, up to the limits of error of experiment. To proceed further, we must make an estimate of the mass of an atom; that can be done, and has been done, in many ways, and we have been taught both by Dr. Johnstone Stoney and by Loschmidt, and notably by Lord Kelvin, that the mass of an atom of water is approximately 10^{-24} of a gramme, wherefore an atom of hydrogen will be approximately 10^{-25} gramme; whence the unit of electric charge is 10^{-21} c. g. s. magnetic unit, or 10^{-10} of an electrostatic unit or 10^{-20} of a coulomb.

I have emphasized this matter of the ratio mass *m* to charge *e* or *e* to *m* because it plays a considerable part in what follows. The absolute values are of less consequence to us than the ratio, and are only known approximately, but the ratio is known with fair accuracy, and the ratio for hydrogen is very nearly 10^4 magnetic units, or more exactly 9,660.

Thus what we learn from electrolytic conduction briefly summarized is that every atom carries a certain definite charge or electric unit, monads carrying one, diads two, triads three, but never a fraction; that in liquids these charges are definitely associated with the atoms, and can only be torn away from them at the electrodes; that the current consists of a procession of such charges traveling with the atoms; the atoms carrying the charges or the charges dragging the atoms, according to from which point of view we please to regard the process.

CONDUCTION IN GASES.

We will now leave liquids and proceed to conduction by rarefied gases, that is to say, to the phenomena seen in vacuum tubes. If a long glass tube, say a yard long and two inches wide, with an electrode at each end, and full of common air, is connected to an induction coil and attached to an air-pump, the ordinary spark-gap of the coil being, say, two or three inches wide, we find that for some time after working the pump the electric discharge prefers the inch or two of ordinary air to a long journey through the partially rarefied air in the tube, but that at a certain stage of exhaustion, one which any rough air-pump ought to reach, this preference ceases. A flickering light appears in the tube readily visible in the dark, which very soon takes on the appearance of red streamers like the Aurora Borealis, and then the sparks outside in the common air cease, showing that the rarefied air is now the better conductor and the preferable alternative path. Let the exhaustion proceed further, and the axis of the tube becomes illumined with the glow, which is now much brighter, showing a band or thread of current, while the original spark-gap may be shortened down gradually to one-eighth of an inch, or even less, without any spark taking place across it, showing that the rarefied air is now a very good conductor. When the best conducting stage is reached the tube is filled with a glow, called the positive column; and both ends of the tube are apt to look alike. If we exhaust still further—and to exhaust even as far as this something better than an ordinary air-pump is necessary, an oil or mercury pump being the most suitable—the column of light is seen to fill the whole tube, to gradually lose its bright red or crimson tint, and to break up into a number of very narrow disks like pennies seen edgeways. At the same time the spark-gap must be widened to something more like a quarter or half an inch to prevent the discharge from taking that path, and a dark space near the cathode now begins to be visible, the cathode itself being covered all over with a glow, while the anode is usually only illuminated at a point or two. The striæ into which the positive column has been broken up thicken and separate as exhaustion proceeds. The dark space near the cathode also enlarges, driving as it were the positive column before it into the anode, and looking as if it would presently fill the tube; but before it can do this it is noticed that the glow on the cathode itself is coming off as a kind of shell, leaving another dark space, a narrower and much darker space, inside it. The first dark space has been called Faraday's dark space; the second is generally known by the name of Crookes'. This second dark space now increases in thickness, pushing the glow before it as the vacuum gets better and better; but the terminals of the spark-gap must now be pulled still further apart, else the discharge will prefer to take a reasonably long path through the air. Exhausting further still, the glow all disappears and the second dark space fills the whole of the tube; and now is noticed a new phenomenon; the sides of the glass have begun to glow with a phosphorescent light, the color of the light depending on the kind of glass used, but generally in practice with a greenish light; a result evidently of being the boundary of the dark space. If exhaustion proceeds further, the resistance of the tube becomes very high, and the spark may prefer to burst through an equal and ultimately even a greater length of ordinary air. This is the condition of the tube so much investigated by Crookes, by Lenard and Röntgen, and by many other observers. It is the phenomena occurring in this dark space which have proved of the most intense interest.

CATHODE RAYS.

So far we have supposed that the cathode is a brass knob or other convenient terminal introduced into the tube; but if we now proceed to use other shapes, as Crookes did, using a flat disk or a curved saucer-shaped piece of metal, and if we then introduce into the dark space various substances, we shall find that the dark space is full of properties which are most clearly expressed by saying that it is a region of cathode rays—that is to say, of rays or something as it were shot off from the cathode. There is evidently something being thus shot off, which, however, is invisible until it strikes an obstacle, something which seems to fly in straight lines and to produce a perceptible effect only when it is stopped. Such a something might be a bullet from a gun, which is quite invisible when looked at sideways, but may produce a flash of flame when it strikes a target, or may do other damage. So it is with these cathode rays; the region of their flight is the dark space; the boundaries of that space where the projectiles strike are illuminated. A substance with phosphorescent power, such as many minerals, or even glass, phosphoresces brightly, and the path of the rays can be traced by smearing a sheet of mica with some phosphorescent powder and placing it edgeways along their path. In this way it can be shown that they travel definitely in straight lines, not colliding against each other, but each shot as it were like bullets from an immense number of parallel guns. Where they strike the sides of the glass they make it phosphoresce; where they strike residual air in the tube, as they do if the exhaustion is not high enough, they make it phosphoresce also, and give, in fact, the ordinary glow surrounding the dark space.

These rays possess a considerable amount of energy, as can be shown by concentrating them by means of a curved saucer-shaped cathode and bringing them, as it were, to a focus. A piece of platinum put at that focus will (if the exhaustion is not too high) show evident signs of being red-hot—that is to say, will emit light. If the exhaustion is higher less heat is produced, though a phosphorescent light is emitted from suitable substances like alumina and most earths; but if the exhaustion is pressed further still the bombarded target emits no visible light but that higher kind of radiation known as Röntgen or X-rays. It may be doubted, however, whether the target itself emits these rays, whether its function is not rather to stop the projectiles as suddenly as possible by the massiveness of its atoms. Thus the best target would be a substance with the heaviest atoms. The X-rays are probably emitted by the suddenly stopped projectiles in a manner which has been investigated both by Sir G. Stokes and Prof. J. J. Thomson, and which is intelligible to anyone who has studied the properties of moving electric charges moving at the speed of light; a matter on which Mr. Heaviside has written with extreme clearness in his volume called "Electromagnetic Theory."

Cathode rays have a remarkable penetrating power; for Hertz found that a thin metal diaphragm, especially if it were of aluminium, was powerless to stop their passage completely; as could be demonstrated by the phosphorescence and other effects appearing in the further half of the tube beyond the diaphragm.

The position of the anode in such experiments is of small consequence. There must be one somewhere and the easiest plan is to make a cylinder through which the cathode ray bombardment goes. The bombarding particles fly in straight lines and decline to turn a corner, taking no apparent notice of the position of the anode, and exhausting themselves by bombarding the side of the glass opposed to them if the tube is bent into a V-shape, for instance.

Lenard extended Hertz's discovery in a remarkable way by skillfully constructing a tube with its outer wall of very thin aluminium, so arranged as to be able to stand the atmospheric pressure outside. He then directed the cathode ray bombardment on to this window or aluminium film, and showed that the rays can penetrate it and actually come outside into the ordinary atmosphere, where they are called Lenard rays, in honor of this indefatigable investigator, a friend and disciple of Hertz.

These Lenard rays make the air phosphoresce and produce the other effects which cathode rays can produce, but they are stopped within a moderate range by the immense obstruction they meet with from a substance of the density of ordinary air. Substances seem to stop them simply in proportion to the quantity of matter which they encounter, without regard to its nature. A thick layer of air would be about as opaque as a layer of water 1-800 as thick; and even if the body put in their way is a solid, provided it is thin enough and not too massive, it will be penetrated by the rays; and phosphorescent effects will be produced on the other side of it. The rays can also affect photographic plates, and indeed do nearly all the things, though on a smaller scale and with much less penetrating power, that the later discovered Röntgen rays can do.

The Lenard rays are clearly cathode rays emerged from the tube, and it was the custom, at the date of their discovery, to think of them as flying charged particles of matter; though the extraordinary distance they could travel through common air, a distance comparable to an inch, was a manifest difficulty to such a hypothesis, seeing that things as big as atoms of matter cannot travel so much as 1-1000 of an inch in ordinary air without many collisions.

Lenard accordingly adhered to the view that they were not material but ethereal; and although in the sense he probably intended this is not a tenable view, for they are not ethereal waves or anything of the nature of radiation, yet, as we shall see, neither are they ordinary material particles, any more than the cathode rays are. But that is just what we are now considering, and we will return to them as observed by Crookes in 1879.

NATURE OF THE CATHODE RAYS.

We have seen that the impact of the cathode rays, speaking in language appropriate to the assumption that they are charged particles, will result partly in heat, or vibration of the impacted particles; partly in light or phosphorescence, due to the quiver of electrically-charged atoms, or rather the electrical charges on atoms, as in the ordinary process of radiation; and partly in X-rays; all of which effects are readily seen at different stages of vacuum in a Crookes' tube. The momentum of the flying particles shot off from the cathode can also be exhibited by putting into their path some form of vane or little windmill, which will then be driven mechanically, as the vanes of a radiometer are driven by the recoil of the molecules of the residual air from the warmer surface, a stress being thus set up between the vanes and their glass inclosure. In the electric vacuum tube experiment the stress seems to be between the cathode or gun and the vanes or target, and the propelling force would appear to be the force of electrical repulsion, the particles traveling down the grade of potential just as they travel in ordinary electrolysis; but whereas in ordinary electrolysis they meet with constant encounters and therefore progress very slowly, in the high vacuum they can fly for several inches in a free path without encountering anything, and therefore without causing any disturbance, giving rise to no appearance but that of the dark space. Phenomena occur only where they strike.

This was the view taken by the whole world of the nature of cathode rays after Crookes' demonstration; it was supposed that they were flying atoms, and that they were flying with ordinary molecular speed, but with a long free path—much longer than would have been expected from ordinary gaseous theory. The extraordinary length of free path was somewhat difficult to reconcile with the doctrine that they were flying atoms obedient to the ordinary laws of gases; except that, being subject to electrical propulsion all in the same direction, their course was more regular, and their encounters therefore fewer, than if they had been moving at random. This same

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* Excerpt from a paper read before the Institution of Electrical Engineers and published in the Journal of Proceedings of the Institution.

† The decimal places are correctly printed above; though the fact that 1 coulomb or 1 ampere-second is one-tenth of a c.g.s. unit, owing to the volt having been stupidly defined as 10^8 instead of 10^9, always stands ready to introduce confusion and error.

feature of regularity it is that confers momentum upon them; their motion does not constitute heat, and is not to be considered as temperature; they are moving like a wind, rather than with the irregular unorganized motion appropriate, and solely appropriate, to the terms "heat" and "temperature," and to the ordinary kinetic theory of gases. Crookes indeed hazarded the surmise, by one of those flashes of intuition which are sometimes vouchsafed to a discoverer but are often jeered at by orthodox science at the time, that he had obtained matter in "a fourth state," and also that he had got in his tube something equivalent to what was contemplated in the "corpuscular" theory of light. There is something to be said for even this last mode of statement, when the particles are moving quickly enough; but how true the first was—that the matter in the dark space was in a fourth state, neither solid nor liquid nor gaseous—how true that was we shall presently see.

Meanwhile let us summarize the evidence with the view that the cathode rays are at any rate charged particles of some kind in extremely rapid motion. That they are in motion must be granted from the facts of their bombardment—driving mills, heating platinum, and the like; and in order to show that they are charged, the most direct plan is to catch them in a hollow vessel connected with an electroscope, as Perrin did; but another plan is to show that they have the properties of an electric current. If they are charged while in motion they constitute a current on Maxwell's theory, and therefore should be able either to deflect a magnet or to be deflected by it; and here comes one of the most simple and important experiments in physics at the present time. A definite form of old experiments by Goldstein and many other vacuum tube observers was arranged by Crookes in 1879, when he made the track of the rays visibly luminous by passing a selection of them through a slit and letting them graze along the surface of a film of mica covered with phosphorescent powder, and when he then brought near them a common horseshoe magnet. When this is done the track of the rays is at once seen to be curved; showing that it is not a beam of light we are looking at, but a torrent of charged particles behaving like an electric current and deflected by a magnet. It is really the same phenomenon as can be observed with difficulty when a current flows through metals, which was discovered by E. H. Hall, and known as the Hall effect.

The fact that the particles are thrown off the cathode, being evidently vigorously repelled by it, is sufficient to suggest that they must be negatively charged; the direction of the curvature caused by a magnetic field enables us to verify at once that the flying particles are negatively charged, and no comparable rush of positive particles in the opposite direction or in any direction has been observed. In that respect evidently the magnetic curvature of cathode rays in gases differs from the magnetic curvature of a current in metals, viz., that whereas in metals it is sometimes the negative and sometimes the positive current which is acted upon, according to the nature of the metal, and is always small, in gases it is the negative alone that appears to be acted upon and the action is always large. It seems, therefore, that for some reason or other the negatively charged bodies in a vacuum tube are much more mobile than the positive, and that the mobility of the negatively charged bodies is extreme. One striking method by which their mobility was displayed consisted in the observation by Prof. Schuster that all parts of gas in a closed vessel became conducting when an electric discharge had taken place in one corner of it, so that even though the vessel consisted of different compartments, one compartment was made feebly conducting by a discharge in the other, provided that the two had any kind of gaseous communication, a fact which looked as if some extremely mobile particles, probably the negatively charged particles of cathode rays, could wander about to a considerable distance in a very short time and take their share in the conveyance of an electric current. The conductivity of gases appeared to be, indeed, entirely due to these loose or dissociated or detached charged particles, and where they were absent the gas did not conduct at all; it could be broken down, being a weak dielectric, by a sufficiently strong force, but it would not leak; whereas, when these loose charged particles were about, it leaked readily, becoming to all intents and purposes an electrolyte amenable to the feeblest electric influence. And the act of breaking down the air by an electric discharge was found to render the surrounding air for a time thus electrolytic. Its electrolytic quality, however, did not last long. The mobility of the particles which enabled them to travel to a considerable distance also enabled them to get rid of themselves by clinging to the sides of the vessel, or perhaps by re-uniting to some opposite but comparatively immobile positive charges, which after some time in their rapid journeys, they must casually encounter. Mr. Townsend,* however, found that the conducting power lasted unexpectedly long if no dust was present; the dust particles evidently acting as intermedial receivers and stores of charge, promoting interchanges, which otherwise might be delayed from accidental non-collision. And the time that thus elapsed before the whole of the conductivity disappeared from dust-free air suggested that the moving particles must be very small, so that collisions were comparatively infrequent.

The mobility or diffusiveness of a gas depends on its mean free path, and that depends on its atomic size; the smaller it is, the more readily can it escape collision. Hence it is the collisions are so rare in astronomy; the bodies are small compared with the spaces between them. The behavior of charged particles seemed to indicate that they must in some cases be something smaller than atoms. It seemed hardly likely that material atoms could behave in the way they did, so it was recollected that it had occurred to some philosophers, among them Dr. Johnstone Stoney, that electric charges really existed on an atom in concentrated form acting as satellites to it; so on that view it was just possible that these flying particles might be not charged atoms at all, but charges without the atoms, the concentrated charges detached, knocked off, as it were, in the violence of the discharge and afterward going about free; traveling at an immense pace because they would still be liable to the full electric force that they had experienced before, and yet would have shaken off the incumbrance of the material atom with which they had been associated. It is true that no such disembodied charges or electric ghosts had ever been observed. All the experiments that had been made in electrostatics had been made on charged matter, the surface or boundary of the matter acting as the locality for an electric charge. The facts of electrolysis had suggested or proved that the atoms themselves could carry charges, and hence that if a liquid were electrified, what was really happening was that a number of the atoms on its surface turned their similarly charged poles outward; and the same might, for all we know, be true for metals also, and thus every charge seemed associated with matter.

Yet at the same time the occurrences at an electrode, where an ion gave up its charge and escaped without it, indicated the *possibility* that perhaps the electric charge could exist alone, at any rate that it could be handed from one atom to another, and thus might conceivably exist alone for an instant. During this momentary isolation some might, in the freedom of a rarefied gas discharge, possibly escape, and wander about free.

To such hypothetical isolated charges, the unit charge or charge of a monad atom, the name "electron" has been given, and when I speak of an electron I mean to signify the at present purely hypothetical isolated electric charge. Whereas by the term "ion" I always signify the atom and its charge together.

Now if the flying particles which constitute the cathode rays were electrons rather than ions, if they were detached charges, leaving the atoms behind them (probably leaving the atoms from which they were detached positively charged), their extreme mobility and diffusiveness and high speed would be perfectly natural; and although they would not be matter in the ordinary sense, yet no difficulty need be felt at their possessing some of the properties of matter, at any rate such properties as appertain to matter by reason of its having inertia, because, as we have seen, an electric charge itself does possess a certain kind of imitation inertia. Hence these electrons in movement would possess momentum, and might therefore propel windmills; they would possess kinetic energy, and therefore might heat a piece of platinum; and if suddenly stopped by a massive target when traveling at a high speed they might readily give rise to phosphorescent appearances, and even to the sudden pulse of radiation known as X-rays. But the existence of this last property ought to be capable of clear deduction on electrical principles if the matter is further gone into.

INCREASE OF INERTIA DUE TO VERY RAPID MOTION.

But now rises the question whether the distribution of charge on a charged body, together with its lines of force, will remain constant and unaltered while the body is rapidly moving; because if the distribution of lines of force is altered, then perhaps the inertia due to their lateral motion may be altered too.

Thus, for instance, imagine that the lines of force of a body in motion became more concentrated toward the axis or line of motion; the effect would be at once to diminish the lateral component of their motion, therefore to diminish the magnetic force which that lateral component causes, and thus to diminish the apparent or electromagnetic inertia of the moving charge.

On the other hand, if the lines opened out and became concentrated toward the equator, or plane normal to the line of movement, then a greater component of their motion would be of a kind suitable to excite a magnetic field; moreover, since both the fields would by this concentration increase in intensity, the whole transmission of energy would be greater, and the inertia would apparently increase.

Thus, then, it may be possible that electric inertia may depend in some fashion on speed, a thing unknown in ordinary mechanics. I do not say that such dependence must be *untrue* in ordinary mechanics, on the contrary, I feel reasonably sanguine that it will be found true for matter moving sufficiently fast, and that it may even have a practical influence on some exceptionally rapid movements in astronomy. But however this may be, there is no doubt that theory points to an increase of electromagnetic inertia at excessively high speeds, and Mr. Heaviside has calculated its amount.

It will be observed that when a charge moves, it generates circular magnetic lines of force. Now these magnetic lines are not stationary, but are themselves moving at the same rate as the body, hence they generate fresh electrostatic lines, i. e., cause an electric displacement away from the axis, which displacement is superposed upon the original radial displacement (away from or toward the center) due to the charge.

At ordinary, at even violent speeds, this second order electric effect is insignificant, but it is there all the time, and must not be ignored when the speed becomes extravagantly high. It rapidly rises into prominence when the speed approaches the velocity of light, but at any speed much smaller than this such a second order effect is vanishingly small.

Its effect will be therefore to alter the distribution of the charge, making it move away from the poles and concentrate toward the equator of the charged sphere, when the speed is very great; ultimately becoming wholly concentrated upon the equator, all the rest of the sphere being denuded, when the speed attains that of light. And the electric lines of force will then be opened out into a fan or equatorial plane, like the spokes of a wheel which is rushing furiously along an elongated axle, the circumference of the wheel representing the direction of the magnetic field.

The magnetic force due to motion can be shown to depend on the ratio of the speed of the motion to the velocity of light, u/v. The secondary electrostatic force due to the motion of this magnetic field likewise depends on the same ratio. Hence the second order disturbance of the original uniform electrostatic field will be of the order u^2/v^2; and whenever we can afford to neglect quantities of this order, the distribution and therefore the inertia of the moving charge continue practically constant.

But when its speed of motion begins to approach the velocity of light, say even no more than one-tenth of that speed, then a perceptible disturbance is to be expected, and something like a 1 per cent increase of inertia must occur.

The complete investigation makes the inertia infinite when the speed reaches that of light, but there is probably no need to press this to extremes, unless the charge were an absolute point; clearly, however, the inertia will then be very great, and possibly therefore it may always be impossible to make matter, or at least charged matter, move with a speed greater than that of light. There may be ways out of this, however, just as it is possible for a bullet to move through air with a velocity greater than that of sound. This is managed by the violent adiabatic condensation of the air in front of such a bullet, the effect being to raise the appropriate velocity of sound to the required value. If there is any way out of it in the case of the ether, however, it is not likely to be *this* way.

It has been shown both by Mr. Heaviside and by Prof. J. J. Thomson that if the speed of motion is ever greater than that of light, the fan or radial plane of lines of force bends backward and becomes a conical surface, gradually closing up as the speed increases; an effect singularly reminiscent of the conical pulse traveling with a sufficiently rapid bullet, and demonstrated in Mr. Boys' bullet photographs.

No known speed which can be conferred upon matter is sufficient to bring this latter effect into prominence. The quickest available carriage is the earth in its journey round the sun, 19 miles a second, or 60 times faster than a cannon-ball; but the earth's velocity is only the 1-10000 of the speed of light, and consequently any spurious inertia due to its orbital motion is only 1 part in a hundred million; and even the accuracy of astronomy could not display any effect of that order of magnitude.

There are stars which move 200 miles a second, but even these have only one-tenth per cent of the speed of light, and the excess inertia will be only 1 part in a million. The only known place where charges or charged matter move at speeds greater than this is in a vacuum tube. There the cathode-propelled particles are flying 20,000 miles a second or one-tenth the speed of light, and they may have 1 per cent excess inertia; or more if they can be persuaded to go still faster.

The substance of the above digression on the effect of rapid motion was written in connection with the Liverpool meeting of the British Association in 1896, and was communicated orally and very briefly to Section A in a discussion on the mechanism of the production of X-rays; for I then thought that unless great speeds, sufficient to disturb the static field, were reached by the cathode particles, they would not serve as efficient producers of the rays when suddenly stopped; but the matter has been gone into more fully now, and not only Mr. Heaviside's Vol. I. of "Electromagnetic Theory," p. 57, may be referred to, where the circumstances of sudden stoppage of a charged body moving with the speed of light are illustrated, but also a paper by J. J. Thomson in the Philosophical Magazine for February, 1898, dealing powerfully with the more general problem.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.*

OSCILLATORY CONDENSER DISCHARGE.—Braun's application of oscillatory condenser discharges to wireless telegraphy has made it very desirable to have a convenient method of determining the period of rapid oscillations of wave-lengths varying from 10 to 100 meters. P. Drude has devised a resonance method which is more accurate than that indicated by Braun and elaborated by Mandelstamm. For short waves, of lengths less than 12 meters, the primary condenser circuit whose period is to be determined excites a secondary circuit consisting of two accurately parallel copper wires, 1 mm. thick, joined permanently at one end, while at the other a metallic yoke can be displaced along the wires until accurate resonance is obtained, as indicated by a maximum luminosity of a vacuum tube laid in the center between both ends. Then the wave-length equals the total length of the secondary circuit plus the length of the yoke plus 3 cm., due to the capacity of the luminous tube. For longer waves, the author uses a parallel circuit 2 meters long, which at one end contains a condenser consisting of two circular plates, whose distance can be finely regulated and accurately determined. The wires are bridged by a movable yoke, and maximum resonance is tested by a vacuum tube applied to one condenser plate.—P. Drude, Ann. der Physik, No. 11, 1902.

DYNAMICS OF THE ELECTRON.—M. Abraham has formulated a dynamical theory of the electron as a basis of an electromagnetic system of dynamics, suggested by Kaufmann's proof that the mass of the electron is purely apparent, and due to electromagnetic inertia. He starts from the supposition that the electron, such as we see it in free motion in the cathode or Becquerel rays, is a sphere of radius 10^{13} cm., in the volume of which the electric "charge"—whatever that may be—is equally distributed. The "electricity" is to be attached to the volume elements of the electron just as ordinary matter is attached to volume elements of a rigid body. The whole dynamics of the electron are based upon a fundamental kinematical equation, the Maxwell-Lorentz field equations, and a fundamental dynamical equation which implies that the resultants of the inner and outer forces and couples vanish. The main differences between these dynamics and ordinary dynamics are that the electromagnetic dynamics are valid for velocities nearly as high as the velocity of light,

* Mr. Townsend, of Trinity College, Dublin, then working in the Cavendish Laboratory, Cambridge, now Waynflete Professor of Physics in the University of Oxford.

* Compiled by E. E. Fournier d'Albe in the Electrician.

whereas ordinary dynamics apply only to small velocities. The author works with a three-dimensional space, an atomic structure of electricity, and a continuous ether. He combines the mechanical equations of Lagrange, and more especially Hamilton's principle, with the Maxwell-Hertz differential equations.—M. Abraham, Physikal. Zeitschr., October 10, 1902.

THE ARCHITECTURAL REFINEMENTS OF ST. MARK'S AT VENICE.*

THE subject of architectural refinements is an unusual one and is of great interest, and is attracting wide attention especially abroad, and through the courtesy of Mr. William H. Goodyear, Curator of Fine Arts, Brooklyn Institute Museum, and its Trustees, we are enabled to present to our readers an abstract of some of the latest discoveries.

The preliminary contributions to the subject of medieval refinements by Ruskin and Viollet-le-Duc were so slight, in comparison to his own, that he may claim the distinction of being the pioneer in an otherwise untrodden field. In fact, the conception that architectural refinements were practised in the middle ages may be said to have originated in his investigations.

Hitherto, that is, before 1870, when Mr. Goodyear's investigations began, the use of architectural refinements was supposed to have been limited to the temples of the ancient Greeks. Even in their case the earliest discoveries of modern students were as recent as 1837, and the earliest publications of definite measurements were as recent as 1851. The architect who made and published these measurements, Mr. Francis Cranmer Penrose, was disposed to consider the Greek refinements as having had for their purpose mainly the correction of optical illusions, and this was notably the case as regards the now famous horizontal curves. The prejudice of modern temperament and of modern architects in favor of mathematically correct and rectilinear building eagerly seized on the proposition of Penrose that the Greek curves were intended to make the curved lines look optically straight and rectilinear. This theory was that the horizontal lines were curved upward to prevent them from appearing to curve downward. It is true that Penrose also suggests that an æsthetic and artistic preference for these delicate curves may have inspired the Greek builders, but this suggestion has received little attention from classroom and professional disseminators of his observations in England and America. The French and German authorities have generally laid more stress on the æsthetic significance of the curves, but since the measurements and observations which they quoted were taken from Penrose, their suggestions have not attracted such wide attention as his own.

On the other hand, Mr. Goodyear's studies have had the great importance of calling attention, within the limits of ancient architecture, to an otherwise neglected class of curves, viz., the curves in plan, as distinct from curves in elevation (rising curves), to which latter class the observations of Penrose had been confined. Mr. Goodyear was the first to point out that the curves in plan at Medinet Habou (which were discovered by Pennethorne in 1833, but not made known until 1878) had not been considered or even mentioned by any accepted theory on the optical effects or possible purpose of the Greek curves, and it is palpable that they bring a new element into the problem of purpose. By Mr. Goodyear's discovery that the lines of the entablature under the gables of the Temple of Concord at Agrigentum are not curved at all, whereas the entablatures of the flanks show the usual curves,† he probably gave the *coup de grace* to the proposition of Penrose that the purpose of the Greek curves originated in the idea of correcting the optical effect of sagging produced by a gable. But it is above all by the discovery of constructive horizontal curves in Italian medieval architecture, under conditions wholly different from those holding in Greek temples, that Mr. Goodyear has probably forced the world of archæology to an ultimate revision of the theories of Penrose.

We thus begin our account of the observations of medieval Italian buildings with the remark that they also react on the theories which have been so largely held by the students of classic architecture. These observations necessarily tend to accent that contention which has been so happily developed by the Sturgis Dictionary of Architecture, viz., that architectural refinements represent a repugnance to formalism, rigidity, and coldness of architectural effect. This formalism is confessedly the most striking and the most objectionable characteristic of modern work; which has been hitherto dominated by the ideal of mathematically accurate symmetry and by the methods of geometrical design.

The discoveries in Italian medieval architecture may thus be considered from several points of view. From a practical point of view they tend to suggest reform of a notorious deficiency in modern building. From a historical point of view they throw new light on the much underrated capacities of medieval artists and builders, and they also suggest the existence, in certain localities, of an unbroken continuity of tradition between the middle ages and classic antiquity, probably through the medium of Byzantine art.

Not the least interesting result of these observations is the point that they indicate considerable obtuseness in that modern taste, which has so long and so strangely ignored the facts which may be fairly said to be open to expert observation in many famous churches.

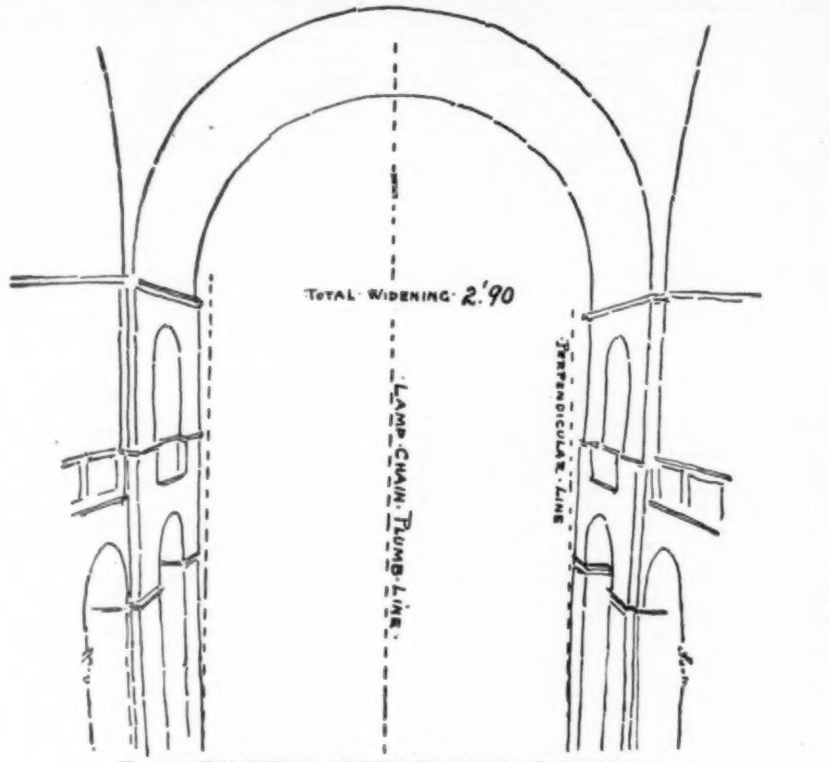


FIG. 2.—WIDENING OF THE NAVE IN ST. MARK'S.

Tracing from the photographic original of Fig. 1. Compare Fig. 3.

The most extensive summary of the general results of these investigations which has ever been published appeared in L'Arte, the most important of the Italian art journals, vol. III., for 1900, p. 137, and was written by Antonio Taramelli, who declares that the publications in the Architectural Record Magazine are an "opera magistrale" (a master-work) and that their author ranks among the first of his nation as an authority on the architecture of Western Europe.

As coming from an Italian writer in the leading art journal of Italy, we shall quote the following list of the various phases of architectural refinements in Italian medieval buildings which have been announced by Mr. Goodyear:

(a) In many medieval churches, the piers which support the vaulting exhibit delicate curves in the vertical lines which are not caused by thrust; important examples are the piers at the transept crossing in the Pisa cathedral and the piers of the cathedral of Vicenza. (b) The survival of the classic entasis in medieval columns; examples at Fiesole and on the exterior of S. Michele at Lucca. (c) An outward inclination of piers or walls of churches not due to thrust, and giving a widening effect to the upper portion of the church; examples in the cathedral of Trani; in S. Eustorgio and S. Ambrogio, Milan; in S. Maria della Pieve, Arezzo; and in S. Mark's at Venice. Several other cases have been published. (d) Forward bends or leans in façades of churches, such as are seen in the cathedrals of Pisa, Pavia, Ferrara, and in the churches of S. Ambrogio at Milan and S. Ambrogio at Genoa. (e) Curves of horizontal lines, some of which are as delicate as those of classic antiquity; examples at Fiesole, Trani, Venice, Pisa, Genoa, Ravenna (S. Apollinare Nuovo) etc., cloisters at Bologna, Verona, etc. (f) A gradual diminution in the height or width of interior arches in the direction of the choir, giving an illusive effect of greater dimension; examples in the cathedrals of Pisa and Fiesole and in Santa Maria Novella at Florence. Some twenty cases have been quoted or published in detail. (g) Lowering the height of the second arch at the crossing of nave and transept; giving an illusive effect of greater dimension; examples at Piacenza, Siena, Pisa, and Florence (S. Maria Novella). (h) An upward slope of the pavement in the direction from entrance to choir; examples in the churches of S. Maria Ara Cœli at Rome; Capella Palatina at Palermo; cathedrals of Siena and Orvieto, etc. Over eighty cases have been noted. (i) Convergence of outer walls and of supports of the nave in the direction from façade to choir; examples in S. Stefano at Venice and S. Giorgio in Velabro at Rome. (j) Some thirty churches offer examples of oblique plans which cannot be explained as representing the bending of the head of Christ on the cross. (k) Numerous other phases of asymmetry, or "symmetrophobia," which cannot be attributed to carelessness or to the use of heterogeneous building materials, and falling under the general explanation of a disposition to avoid formalism and coldness of effect. The proofs recently published of constructive purpose in the Leaning Tower of Pisa belong to this class of observations.*

The entire number of churches in which well-

FIG. 1.—WIDENING OF THE NAVE IN ST. MARK'S, VENICE.

The nave in parallel perspective; from a Brooklyn Institute Survey photograph of 1895. The widening amounts to 2 feet 10¼ inches at the transepts. Compare Figs. 2 and 3.

* The Architectural Refinements of St. Mark's at Venice. With remarks on other Churches Showing a Similar System of Leaning Verticals; especially those in Orvieto, Vicenza, Milan, Pavia, Bologna, and Arezzo, and including the Renaissance Church of S. Giorgio Maggiore at Venice. By William Henry Goodyear. Published for the Brooklyn Institute of Arts and Science by the Macmillan Company.

† Journal of the Archæological Inst. of America, VI., 2, p. 174.

* Journal Archæological Institute of America, VI. 2, p. 190.

established cases of architectural refinements have been found is mentioned as one hundred and thirty, aside from the large number which exhibit the sloping pavement. The entire number of churches examined in Italy is considerably over eight hundred. Mr. Goodyear's publications have laid stress on the large number of churches in which no refinements have been found. As the American Architect has well remarked in its recent review (March 28) of Memoir No. 2:* "The most unanswerable argument of all against this convenient theory [of thrust or settlement] is to be found in the fact that not all, or even the greater part, of the medieval churches of Italy show such variations, the rule having been, apparently, in the middle ages, as now, to build walls and piers straight, plumb, and symmetrical, and the leaning piers, columns, and walls being found principally in the buildings designed and carried out by the greatest artists of their time."

The memoirs now in publication by the Brooklyn Museum are distinguished from the earlier publications of Mr. Goodyear on this topic by the fact that each one is devoted to an individual church or cathedral; although corroborative facts from other churches are not excluded. Each memoir, so far published, has also been accompanied by a certificate from the architect at present in charge of the given building, which verifies the published facts as being phenomena of construction, not due to accident. Such a trustees, the so-called "widening refinement," as mentioned under schedule c of Taramelli's list, is now abundantly proven to be a constructive feature of St. Mark's. The one simple fact that the entire spread of the nave is shown by detailed measurements to be very nearly three feet, is sufficient to carry conviction as to the facts of construction. The disintegration and collapse of the vaultings and of the domes supported by them would have ensued, had such an outward spread in the supports of the church been produced by accidental causes. But neither have the crowns of the arches subsided, nor are there even fissures of small amount in mosaic surfaces, which in many cases date back to the earliest decoration of the building.

Moreover, the widening refinement in St. Mark's differs from that of any other church which has been examined, in the fact that there are two intersecting systems of widening. The system of the nave (spreading north and south, Figs. 1, 2, 3) is repeated by parallel leans in the north and south walls of the transepts (Fig. 4). But the transepts have also an independent widening, transverse to that of the nave. Hence a series of intersecting or double leans, which are carried into the angle pilasters of the transept aisles and into the pilasters of the transept end walls in most marvelous fashion. These intersecting or double leans also occur in the nave at the points of the transept crossing. We reproduce from a series of of the three other transept arches in corresponding positions.

Letters of most enthusiastic character, addressed to Mr. Goodyear, have been received since the publication of Memoir No. 2 from Italian experts who are in daily contact with the church, one of which was from Prof. Pompeo Molmenti, the president of the Venetian Academy of Fine Arts. (As a member of the Italian Chamber of Deputies, Molmenti has recently delivered an address before that body on the fall of the Campanile.) The memoir is termed "an interesting and colossal work which has no parallel with us." Molmenti writes: "Every Italian must be grateful to you for the profound study which you have devoted to his country's art. But this gratitude must begin with Venice."

As regards the purpose of the widening refinement, we quote from the American Architect of March 28, as follows: "The professional man, in preparing the revision of his ideas of architectural propriety which he sees to be inevitable, will undoubtedly recall other instances where the accepted notions have been called in question. Mr. Goodyear, to our mind, gives us the key to the whole question in saying that the essence of these refinements may probably lie in the feeling which leads us to prefer a freehand drawing to a mechanically executed architectural elevation. More than this, every architect knows how much more satisfactory his first freehand sketch of a building or a

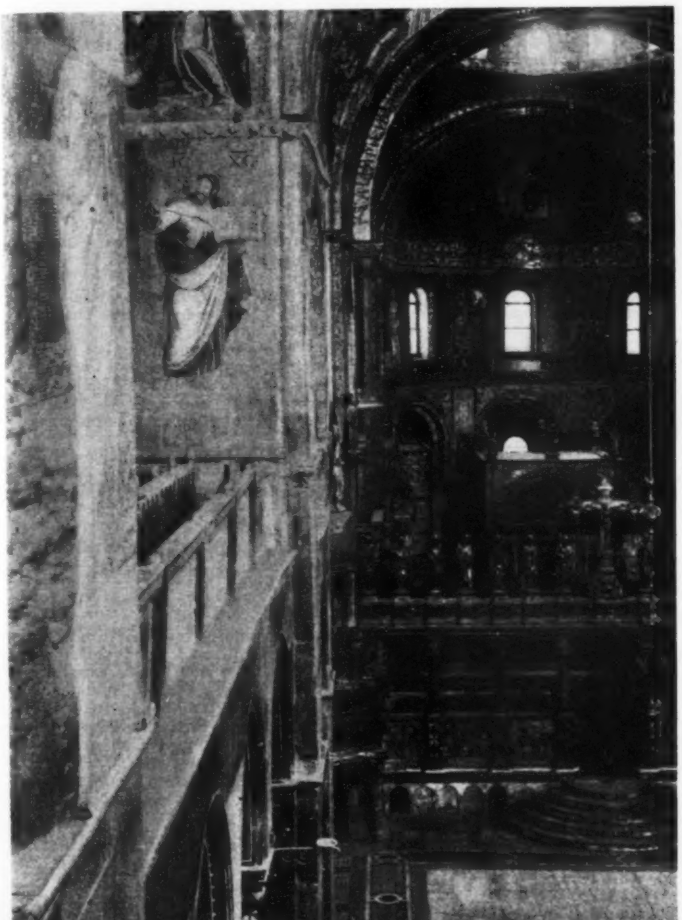


FIG. 3.—NORTH SIDE OF THE NAVE OF ST. MARK'S.

From a Brooklyn Institute Survey photograph of 1901. As compared with Fig. 1 (which shows the widening, but does not include the bend), this view shows the outward bend, contrasted with the nearly perpendicular lower piers in the nave. The lamp chain furnishes a plumb-line. The curve in elevation of the gallery string-course and parapet is also shown.

FIG. 4.—ST. MARK'S—SOUTH WALL OF THE SOUTH TRANSEPT, LOOKING EAST.

Wash Drawing from a Brooklyn Institute Survey photograph of 1901. The plumb line hanging on the pilaster records a lean of 15 ⅘ inches (in about 33 feet). The adjacent column leans 0.23, or under 2⅘ inches. The arches are true. The wall as plumbed near the center leans 13 inches, not including the parapet; line of 30 feet. The measurements (in foot decimals) under the drawing represent plumbs from the pavement with a line of 15 feet. Compare Fig. 5.

certificate is especially valuable in the instance of St. Mark's at Venice. For although the fall of the Campanile has now been formally announced by a government commission† as not having been caused by any movement of the foundations, such movements are always to be considered as possible or probable causes of deviations from the true perpendicular or horizontal, unless the contrary is definitely established. Both the horizontal curves and the vertical inclinations of St. Mark's are now definitely established as constructive; not only by the demonstrations of the author of the memoir, but also by the certificate of an expert authority, resident in Venice and in daily contact with the church.

As shown by our illustrations, which are reproduced from the memoir by the courtesy of the Museum fourteen ground-plans found in the memoir (which also contains forty-four views of the church) a single one which shows the south end wall of the south transept (Fig. 5). This is the same wall which is shown by Fig. 4. The measurements represent the leans as measured from the pavement with a line of 15 feet in length, about half the height of the gallery. Plumbs taken from the level of the gallery (Fig. 4) verify the continuation of the leans with the same inclination up to that level (above which the walls and piers at the ends of the transepts are generally or nearly perpendicular). In Fig. 5 the darts indicate the double directions of the leans, and a corresponding plan published in the memoir illustrates the same facts as being found in the north transept. The mere inspection of these plans is sufficient to carry conviction as to the intentional construction. It will be noticed also in Fig. 4 that the transept arch adjacent to a wall which leans over 15 inches is perfectly true. The spread of a foot in this arch would have involved its downfall. The same point holds detail is than his subsequent geometrical drawings, and the labor which he goes through in trying to infuse into the stiffness and dryness of the latter some of the ease and charm which came so naturally in the sketch. We must remember that the medieval architects were assiduous sketchers and modelers from nature, and hard precision would be likely to offend them even more than it does us, so that the greatest of them seem to have had the courage to do what no modern dares to attempt, and build, so to speak, in free hand. It is common to say, in discussing the medieval refinements, that no modern workman could comprehend or carry out such refinements. With this view we do not wholly agree. It is much easier than most people would imagine for a mason to give a certain batter to a wall, or to lay a string-course, or cornice, with a given 'crown,' and, being constantly occupied with their work, the more observant gain an æsthetic, as well as a mechanical, comprehension of it, which would enable them to understand more than might be supposed of an archi-

* Memoir No. 1 by the same author is entitled "A Renaissance Leaning Façade at Genoa," 1902.

† The true causes are described in the Architectural Record, Vol. xii. No. 7, 1902.

tect's ideas. . . . If, therefore, the architects will take courage to build with picturesque refinements, there is little danger that the workmen will not soon learn to understand them. We still have a remnant of the medieval tradition in the office rule that a semi-circular arch should always be struck from a center above the springing line; and it would not be a very long step further to give a slight entasis to the piers supporting it."

Space will not permit of our giving a more detailed account of the horizontal curves of St. Mark's. We must be satisfied with reproducing one of them (Fig. 6), which is expressly mentioned as an æsthetic device and as an intentional construction in the certificate from Commendatore Pietro Saccaro which is published in the memoir. It is obvious to every intelligent person that this curve could not be the result of thrust or of settlement. It will also be obvious to every student who is familiar with the rising curves best known in Greek temples, that the theories of Penrose which have so far attracted most attention could not be called upon to explain this deflection in the ground plan of St. Mark's façade.

In conclusion, it should be mentioned that the Brooklyn Museum boasts of a unique exhibit of over three hundred photographic enlargements, representing the results of the Brooklyn Institute surveys in Italy. Thirty-four of these enlargements represent the plumb measurements and curves in St. Mark's. Forty-five enlargements relate to the Pisa cathedral, concerning which a third memoir is now in preparation.

BACTERIA AS COLOR-MAKERS.

A CONSIDERABLE number of bacteria produce coloring matter, oftentimes of a gay and vivid quality, and because of this uncommon characteristic their close observation affords a certain charm, both to the micro-biologists and the more common mortals who have an opportunity to investigate their cultures. These miniature color manufacturers may be classified under two heads. In the first or majority class the coloring matter remains in the interior of the manufacturers themselves, who therefore appear to be tinted or tinged with their respective colors; in the other or minority class the newly compounded colors are transferred to the surrounding medium, which becomes more or less vividly stained, while the bacteria-coloring remains pale or even colorless.

Each species possesses a color peculiar to itself; citron-yellow is the exclusive property of the *micrococcus luteus*, gold-yellow is monopolized by the *bacillus luteus*, while a great many species produce a brilliant red; rose-red, however, is made and marketed by a guild with the awe-inspiring title *micrococcus prodigiosus;* sky-blue exudes from the bodies of the *bacillus of blue milk*, bluish-green is developed by the creatures with the euphonic appellation *bacillus pyocyanicus*, and as we near the colors of higher wave frequency, either the stock of these strange sounding names has given out or the microbes themselves have protested against such unintelligible advertising and demanded brands more in keeping with their evident characteristics for we now find violet to be generated by the *bacillus violaceus*, brown by the *bacillus bounneus* and fluorescent-green by a very minute creature with the very lengthy name of *bacillus fluorescens liquefaciens*. What a display of color! It reminds one truly of the palette of a Makart or a Meissonier.

The nature of these dyes is for the most part little understood; the majority seem to belong to the *lipochromes*, that is the class of fat-soluble dye-stuffs. All these manufacturers produce their wares equally well

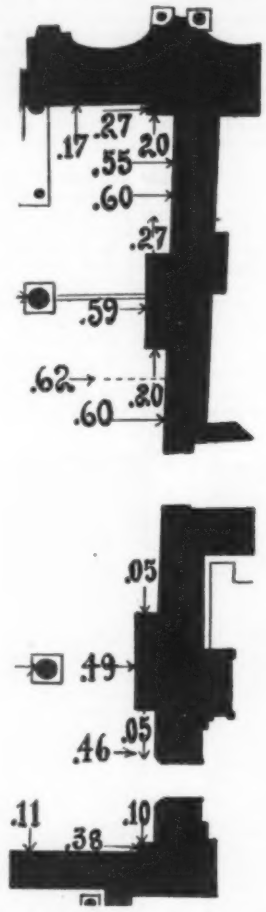


FIG. 5.—PLAN OF SOUTH WALL OF SOUTH TRANSEPT OF ST. MARK'S.

With plumb measurements from the pavement in foot decimals, for a line of 15 feet (entire height of the wall is about [illegible] feet). These measurements represent the intersection of the north and south widening system with the east and west widening system. A view of the wall is shown by Fig. 4.

in the dark as in the light, provided only they have some oxygen to draw upon. An elevation of the temperature acts obstructively upon them, and if the rise be above 35 deg. C., they produce only sparingly or not at all. Of these minute color-makers, the best known is, strange to say, the seemingly paradoxical *bacillus prodigiosus*, whose beautifully brilliant red colonies often appear in food-stuffs, bread for instance. To this microbe is now ascribed the blood-red spots which have from time to time been seen upon the sacred wafer or Host, and which were at that time attributed to supernatural influences, as its name "Bleeding Host" indicates. The power of considerably altering its shape is also possessed by this animalcule, for sometimes it appears in globular form, again elliptical, and it may even cause its structure to be elongated into a sort of small staff or rod. Its cultivation presents no difficulty and it takes kindly to a variety of substances as a base; it will live as an *anaerobe* even when deprived of oxygen, though under these conditions it has ceased to produce any color. The cultivation of these bacilli is greatly retarded when the temperature rises as high as 30 or 35 deg. C., and if continued long at that mark the formation of color ceases entirely. Pungent odors of ammonia or trimethylamin are given off from the cultures. Inclosed within the body of the *bacillus prodigiosus* is the coloring matter, and only with the death of the maker does it appear, and then in a granular form spreading itself throughout the surrounding medium. It is insoluble in water but dissolves easily in alcohol or ether; acids change its color first to carmine, then to violet, while the effect of alkalies is to produce a yellow. Exposed to the light they fade rapidly. The *bacillus prodigiosus* has been known to attack the whole stock of a bakery ; in 1843, in fact, it attacked a magazine containing the soldiers' bread and the entire supply was colored red.

In this connection let us revert to some memorable acts and events chronicled in ancient and medieval history, happenings which, though now known to have been the work of these microbes, were then laid to supernatural agencies, and not infrequently used to wreak the vengeance of religious fanatics upon an innocent people. The "bloody bread" as long ago as 332 B. C., struck terror to the hearts of both soldiers and populace alike at the siege of Tyre conducted by Alexander the Great. In the Middle Ages, too, when blood-red spots appeared upon the Host, it was, in numerous instances made a pretext to fall upon, maltreat and even massacre the innocent and defenseless Jews, as was done at Berlin in 1540, where no less than thirty-four Jews were ruthlessly murdered because of the "Bleeding Host." Also were undertaken many pilgrimages to localities where "Bleeding Hosts" had made their appearance, e. g., to Wilsnack in the Prignitz in the year 1388, and also to Bolsena in Italy, which "Blood Miracle" Raphael has immortalized in his famous painting.

No less famous is the *bacillus syncyanus* which causes the phenomenon of blue milk or "witch's milk," as it is sometimes called. On the upper surface of the milk one plainly sees one after the other, sky-blue spots arise soon to mix with the cream. Butter made from this cream has a greenish cast and emits an unpleasant rancid odor. Good butter for table use, so they say, may, however, be made of this blue cream if 0.5 gramme of acetic acid be added to each liter of cream.

Examined under the microscope the *bacilli of the blue milk* appear in the form of very small rods or staves rounded off at either end; they are lethargic in their movements and congregate into colonies (zooglœæ) which are surrounded and bound together by a gelatinous or slimy coating. Rare forms are assumed by these tiny creatures when placed in certain solutions. At times they become flat like a ribbon, wave like, and again they will puff up at one end like a balloon. The pigment generated by them is not soluble in ordinary water, alcohol, or ether, but if the water be slightly acidulated it dissolves readily, but the solution fades or loses its color very quickly when exposed to light. Besides the blue dye a small amount of green fluorescent substance appears.

The *bacillus polychromogenes* also merits attention here and because of its ability, as discovered by Macé and Thiry, to produce a great variety of colors (as signified by its name *polychromogenes*) easily and at ordinary temperatures without the aid of any special chemical or physical exciter.

Upon the customary nourishment, perhaps however not with regular frequency, it brings forth blue, violet, red, yellow, and green in varied spectral shades. Upon solid nutriment one can easily perceive small piles of crystalline formations of beautiful saturated indigo blue, similar in form and appearance to urinal indigo ("Harn-indigo"). This bacillus is present in the water of wells and in all water ducts.

The *bacillus violaceus* is generated in water too, and investigation seems to prove that it thrives in the air also, for it has been found in the water from melted hailstones. Only when cultivated upon a substantial base (gelose) do these microbes produce any coloring matter. They are devoid of color in fluids, nor do they color their cells, but rather the gelatinous mass which envelops them and binds them into *zooglææ* or colonies. Their dye is not water-soluble, but dissolves in pure alcohol and gives a beautiful violet coloring closely resembling the tone of aniline-violet. If these bacilli are propagated through several generations on gelose their inherent property of producing color gradually diminishes and finally ceases altogether, though it may be regenerated if the base of cultivation is transferred to something more solid, as slices of potatoes.

Van Tieghem discovered a green bacillus in the water which filled the cavity of the fleshy cap of a *polyporus*. It is greatly to be regretted that none has been seen since, especially as the discoverer declared that the dye prepared by these microbes was very nearly akin to that produced by the chlorophyllaceous protoplasms, from which he concluded that these bacteria were more nearly related to the algæ than to the fungi, to which they are generally assigned. A thoroughly scientific investigation of these dyes is much to be desired.

The *bacillus fluorescens liquefaciens* exists in quantities whenever decomposition is in progress, in the water, in the air, or on the immediate surface of the

FIG. 6.—ST. MARK'S FAÇADE.

From a Brooklyn Institute Survey photograph of 1901. Showing the bend or curve in plan, concave to the Piazza. The amount of curve is 10 inches.

earth. It derives its name from its property of producing a most beautiful fluorescent green color and also of imparting a certain fluidity or liquefaction to the base upon which it is cultured. Its general appearance is that of a slender rod rounded on both ends. These minute rods possess the power of locomotion and are often united in twos. Their original or proper color seems to be blue, though, in consequence of the ammonia developed by the putrefaction, it is converted into a green.

In the air is often found a sort of yellow bacillus, which deposits yellow spots upon the gelatinous propagating disks. Another yellow bacillus occurs in scalded milk to which it imparts its color. While all the above mentioned color makers belong to the family *bacilli*, or little rods, as the name signifies, there are also manufacturers of color among the *micrococci* whose chief characteristic is a rounded or spherical body like a little berry, also indicated in the name. Of these the *micrococcus roseus* is widely disseminated throughout the air. They often produce upon the propagating plates small roseate buttons which frequently have a small wart in the center.

The orange-colored *micrococcus* belongs to the tribes found most frequently in the air; the yellow *micrococcus* makes its appearance often on slices of raw potatoes, while the blue *micrococcus* favors slices of boiled potatoes which have been exposed to the air for a time. Not alone among these, but also among their near relatives, assembled under the names *Sarcina* and *Cladothrix*, do we find color makers.

Worthy of special notice are the manufacturers of the purple dyes and named by Winogradsky, *sulfobacteria*, but assigned to the genus algæ by other botanists. By virtue of their bacterio-purpurin they are dyed while yet in their protoplasmic state. According to Jean Friedel, neither in the different species of this family nor in the individuals of the same colony is the shade of color the same. The color shades from bluish purple into brownish and the bluish purple seems to indicate a specially luxurious vegetation of the species. This protoplasmic pigment, like chlorophyll, enjoys the peculiar distinction of taking part in the assimilating process, a fact established beyond peradventure by Engelmann. The coloring matter of the brown, blue, and red algæ is not capable of this action; these plants assimilate only through the medium of the chlorophyll which exists alongside of their appropriate colors. To place the above-mentioned bacterial dyestuffs upon the same plane with the bacterio-purpurin is utterly out of the question; for they are completely inactive or dormant in the organism and only products of decomposition or excrement.

Bacterio-purpurin never occurs in company with chlorophyll. If dried quickly, in moderate temperatures it continues to preserve its color tolerably well. A spectrum of the bacterio-purpurin exhibits characteristic bands in the orange, green, blue, and violet. The band produced in the red by chlorophyll is totally absent here. In the neighborhood of the infra red rays is a strong absorbing band which is also wanting in the chlorophyll spectrum, though several other bands appear in the ultra-violet.

All the purple bacteria are affected by the action of light and the higher their color the more intense is the light's action. In the dark they are quiescent and remain united in colonies, but when brought to the light they become active.

As we might have guessed from their spectrum the different light rays do not act equally upon the purple bacteria. If a spectrum be thrown upon a culture-disk or solution under the microscope the observer will see these microbes proceed to group themselves in companies, assembling in the positions which correspond exactly with the absorbing bands visible in the bacterio-purpurin spectrum. This preparation may now be dried and it will furnish a *bacterio-spectrogram*. In this manner it may be demonstrated without danger of contradiction that the largest congregation of the bacteria corresponds with the absorbent bands in the infra red rays though the bands in the visible portion of the spectrum are also covered. From this we conclude that the only light rays of value to the purple bacteria are the same which the bacterio-purpurin absorbs.—Translated from Prometheus, Berlin, for the SCIENTIFIC AMERICAN SUPPLEMENT.

A HUGE MAP OF PARIS.

A NEW plan of Paris has been drawn up, on a scale of two millimeters to the meter; and the result is a map measuring 23 x 18 meters—big enough to cover the surface of a large building. It has been divided into 800 sheets, each of which is so broad that it is necessary to lie upon it in consulting it. The houses and yards are indicated in all their proportions, as well as the streets and sidewalks. The plan has also been divided into as many sections as there are houses—which makes 88,587 sections.

The only other cities possessing such a well-executed plan are Berlin and Moscow. According to a report received from the Mutual Life Insurance Company, the work has been completed within eighteen months, by several architects, under the supervision of Mr. Taxil, Chief Surveyor, and Mr. Lauger.

The information about the personal tax assessed on Parisians is interesting. It is shown that while in 1805 the residents of Paris paid not more than 1,000,000 francs, the total payments on that account had increased in 1869 to about 9,000,000, while in 1901 they exceeded 33,000,000.

The area of Paris is 7,812 hectares.

At the beginning of the century there were 84,882 private houses; 1,316 factories, and 2,389 buildings used partly as factories and partly as residences, or in all 3,705 factories, which is much too high a figure from a hygienic point of view.

As to the values of lands and houses, it is generally believed that the Paris houses are worth more than the ground on which they stand. This is true only in the poor districts, such as the 20th arrondissement. In the rich districts, on the contrary, the ground is worth more than the finest residences; which explains why all the buildings are so easily purchased with a view to demolition, and have new ones erected in their place, with all modern conveniences, whereby the rentals are increased and even doubled. In the whole of Paris, the ground occupied by buildings is worth a little more than seven milliards (7,000,000,000) of francs; and the buildings are worth only 6,715,000,000. The value of unoccupied lands is 210,000,000.

Would one believe that there still remain in Paris, outside of gardens and parks, 259 hectares of properties lying fallow, on which the equivalent of a provincial town could easily be built? But it should be said that such lands are situated in out-of-the-way districts, such as La Maison Blanche.

The price of land in Paris is very hard to estimate. An average per district has been taken from the most accurate calculations, which, however, can be disputed; pointing out, for instance, the fact of a company purchasing at any price a particular building situated on the Boulevard des Italiens or in the neighborhood of the Bourse, with a view to destroying it and replacing it by a new structure, the price of the ground being thus brought up to 4,000 francs per meter. Such transactions, the interest of which goes beyond the limits of a contractor's calculations, can hardly be taken into consideration. The frontage being in a location favorable for a wealthy company, is worth more than the interest on the money invested in that manner.

As a matter of fact, the price of land is less than is commonly supposed, viz., 1,718 francs per meter on the Avenue de l'Opera and Boulevard des Italiens (the highest price); 1,511 francs near the Palais Royal (where the prices are decreasing); 1,431 francs at the Halles; 1,396 francs in St. Germain l'Auxerrois; 1,302 francs on Rue Vivienne; 1,141 francs on Place Vendome; 1,024 francs in the Mail district. All other prices are less than 1,000 francs. In the district of the Champs Elysées the average price is 529 francs per meter, and double that on the Avenue.

There still remain cheap plots of ground in Paris, as, 41 francs per meter at Belleville; 45 francs in the Saint-Fargeau; 65 francs at Javel; 151 francs at Auteuil; 243 francs at La Muette. Twenty years ago there could still be found plots of ground at 50 francs per meter between Passy and Auteuil; which shows that the purchase of land is generally a good investment, as its value can be quadrupled within twenty years in some districts. On Avenue Kleber land was worth 3 francs per meter at the time of the Empire, while in 1875 it was valued at 30 francs, and to-day it costs from 500 to 600 francs.

COMMERCIAL RELATIONS OF THE UNITED STATES AND CHINA.

APPARENTLY about one-fourth of the exports from the United States to China ultimately reach the port of Newchwang, the treaty port through which northeastern China, including Manchuria, receives most of its foreign merchandise. This is the conclusion of the Treasury Bureau of Statistics after a careful study of the statistics of the imports of China, as presented by the annual Yellow Book, entitled "Maritime Customs of China; Returns of Trade and Trade Reports for the year 1900-1."

An accurate determination of the question of the share of American imports into China which enter Newchwang is difficult, because of the fact that nearly all of the foreign merchandise reaching Newchwang is first received at some other port of China, chiefly Shanghai, and thence transshipped to Newchwang. Another difficulty lies in the fact that the Chinese customs reports do not indicate the country of origin of the articles imported, except in a few articles. Four articles are specifically named as of American production, viz., American drills, American jeans, American sheetings, and American oil. These four articles, however, apparently form a very large proportion of the imports into Newchwang of American products. Our own statements of exports to China show that cotton goods and mineral oils form about 85 per cent of our exports to China. By an examination, therefore, of the figures of Chinese imports of American drills, jeans, sheetings, and kerosene oil, and the trans-shipment thereof to Newchwang, it is possible to get a fairly accurate estimate of the value of American products reaching Newchwang, the principal port of entry for the country in question.

The Chinese figures analyzed by the Bureau of Statistics show that the value of cotton goods imported into Newchwang direct from the United States was but 3,787 haikwan taels (value of tael, January 1, 1903, 59.4 cents). Of the receipts at Newchwang from other Chinese ports, however, the value of articles named as of American production was, in 1901, as follows:

Articles.	Value. (Haikwan taels.)
American jeans	157,419
American drills	1,966,043
American sheetings	3,526,412
American kerosene	541,485
Total	6,191,359

An examination of the statistics of the receipts of these four articles of American production at the ports which import direct from the country of origin shows that the total value of these articles received into China from foreign countries was, in 1901:

Articles.	Haikwan taels.
American jeans	245,628
American drills	4,904,590
American sheetings	7,665,617
American kerosene	8,644,534
Total	21,460,369

Of this total of 21,460,369 haikwan taels, representing the value of the four articles named and reported as having reached China in 1901, 6,195,146 haikwan taels' value, or 29 per cent, reached Newchwang, and all of it except 3,787 haikwan taels by trans-shipment from other ports, chiefly Shanghai. The total value of these four articles which entered China in 1901 is, as already stated, 21,460,369 haikwan taels, out of a grand total of 23,529,606 haikwan taels' worth of imports from the United States in that year.

The facts here indicated would seem to justify an estimate that about one-fourth of the American goods entering China ultimately reach the treaty port of Newchwang for distribution. That this importation of American products into Newchwang has had a steady growth is shown by the following table, which presents the value of American drills, jeans, sheetings, and kerosene oil imported into Newchwang in each year from 1896 to 1901, the very small figure for the year 1900 being, of course, due to the war conditions which existed at that time.

Value of American jeans, drills, sheetings and kerosene oil imported into Newchwang from foreign countries and from other ports of China, 1896 to 1901:

	Haikwan taels.
1896	2,249,876
1897	3,426,238
1898	3,665,257
1899	6,359,154
1900	2,213,588
1901	6,195,146

The following table, also from the Chinese official returns, gives the total value of imports into Newchwang from foreign countries and from native ports, respectively, 1896-1901:

	From Foreign Countries. (Haikwan taels.)*	From Native Ports.
1896	1,886,485	9,665,940
1897	1,641,415	10,987,030
1898	1,453,318	13,627,199
1899	5,279,185	22,543,087
1900	2,682,420	8,562,998
1901	4,293,737	19,329,723

PROCESS FOR EXTRACTING BISMUTH FROM ITS ORES.

THE practical execution of the process is effected as follows: A series of wooden receivers or vats, each furnished at the bottom with an appropriate filter, is installed in such a manner that the contents of the higher may flow successively into the lower and pass through the filter. The installation is therefore in stories. In each of these vats a ton of bismuth ore is poured, which has been previously finely ground; afterward, a mixture of sulphuric acid, water, ordinary salt, and saltpeter is added to the upper vat. This solution flows gradually through all the vats, while the chlorine which is disengaged sets at liberty all the bismuth contained in the ore, so that the liquid which flows from the lower vat into a receiver consists of a concentrated solution of bismuth.

This collecting receiver contains water, and as soon as the bismuth solution comes in contact with the water, decomposition occurs, with formation of chlorhydric acid and a milky white deposit of bismuth oxychloride. This deposit, after desiccation, may be employed as bismuth oxychloride, or it may be converted into metallic bismuth by suitable fusion in presence of lime or charcoal, and then put on the market in the form of bars of bismuth.

This process may serve also with modifications for treating ores, such as the sulphide and polysulphides of bismuth, having a proportion of tin, etc., which are submitted previously to roasting.

The proportions in which the different matters enter into solution are quite variable. They conform to the nature of the ores treated.—La Revue des Produits Chimiques.

QUEER KINDS OF BREAD.

ACCORDING to La Science Illustrée there are more kinds of bread than dreamed of in our technology.

Bread made of pure oats with the addition of one-fifth of its weight of wheat has all the appearance of the best qualities, but its color is gray and its taste and odor are not especially agreeable. . . . .

Maize flour can be made into bread, but it must be mingled in equal parts with that of another cereal. . . . Half maize and half wheat makes a very agreeable and nutritious bread, easy of digestion and keeping fresh a long time. Bread of good quality can also be made by mixing maize flour and mashed potatoes.

To make bread of rice, several handfuls must first be taken and boiled to a thick glutinous soup. When this has partly cooled it is poured on the rice flour, and salt and yeast are added. . . . During fermentation this dough, which is at first firm, becomes so soft and liquid that it would be impossible to make bread of it unless the hot oven were ready. . . . The baked bread has a fine yellow tint . . . and is agreeable to sight and taste. . . .

The potato, mixed with wheat or maize, gives a very palatable bread, but it attracts humidity and easily becomes soggy. . . .

In Corsica bread is made from chestnuts, without admixture of any other substance. It has not the firmness of ordinary bread, but is healthful, sweet in flavor, agreeable to eat, and easily digestible. It keeps more than fifteen days, and constitutes the chief food of the Corsican mountaineers.

At different epochs attempts have been made to make bread of the seeds of divers leguminous plants.

From the hygienic point of view the mixture of these farinaceous elements with cereals must be recommended, for by their richness in albumen and in nitrogenous matter these legumes furnish a bread as nutritious as that of wheat; but it may be foreseen that it will have the inconveniences of being heavy and difficult of digestion, and that it will become quickly hard, dry, and brittle.

To obviate this, we may take a hint from the experiments of Lehmann on bread made with sprouted grain, which he prevented from becoming heavy and soggy by adding cooking-salt.

Using this same principle, experiments made on various proportions of cereals and legumes have shown that the best bread of this combination is made

* Average value of haikwan tael for 1901 is given by Chinese report as 72 cents; for 1903, by United States Director of Mint, 59.4 cents.

when 2 per cent of salt is added to a mixture of two-thirds rye flour and one-third flour of some leguminous vegetable (beans, peas, etc.).

RADIUM AND OTHER RADIOACTIVE SUBSTANCES.*

By WILLIAM J. HAMMER.

To the discovery of M. Henri Becquerel, member of the Institute of France, in 1896, of those remarkable radiations emanating from uranium, the science, if we may so term it, of radioactivity, owes its foundation.

Great importance must, however, be attached to the previous investigations into the phenomena produced on the interior and exterior of vacuum tubes of various kinds by such men as Varley, Hittorf, Crookes, Lenard, Röntgen, Hertz, J. J. Thomson, Goldsmith, Schmidt, Ebert, Puluj, Perrin, Villard, Wien, Wiedemann, Majorana, Birkland, Deslandres, Poincaire, Edi-

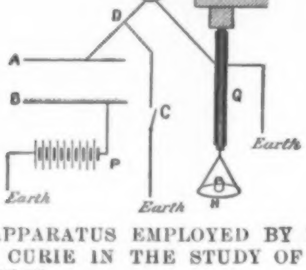


FIG. 1.—APPARATUS EMPLOYED BY M. AND MME. CURIE IN THE STUDY OF RADIO-ACTIVITY.

son, Tesla, Rowland, Michelson, E. A. Thomson, Moore, Rollins, Campbell, Swinton, and others, which had already wrested from Nature so many secrets bearing upon the constitution of matter and paved the way for the Becquerel rays.

Two important links in the chain were supplied by the experiments of M. Henry† and M. Niewenglowski.‡ The former showed that phosphorescent sulphide of zinc penetrated black paper and affected a photograph plate, similar to Röntgen rays; and the latter in his experiment replaced the usual cover of a loaded photographic plate holder by a thin sheet of aluminium; on top of this he placed four glass squares sprinkled over with sulphide of calcium rendered phosphorescent by exposure to sunlight. A jeweler's glass bell jar was put over each plate, and the whole apparatus was then placed in a dark room for twenty-three hours. On developing the negative, the plate showed an excellent image of the squares of glass and the bell glass covers which had been made through the aluminium, a substance heretofore supposed to be entirely opaque to light, the white line shown bordering the squares of glass (where the plate had not been affected) indicated that the rays had here been bent or refracted in passing through the edge of the glass, demonstrating that he was only dealing with ordinary light rays.

Subsequently, Prof. Becquerel investigated the effect of the phosphorescent substances on photographic plates covered with black paper, such as is used for covering X-ray plates; and which while transparent to X-rays is impervious to ordinary light waves (a plate so protected may be left in the sunlight for twenty-four hours); and he exposed various uranium salts to sunlight to try their effect, at times placing an aluminium, copper, or glass plate between the paper and the photograph plate or film. On one occasion after he had placed some double sulphate of uranium and potassium on a photographic plate, the weather became stormy, and he placed his plate with

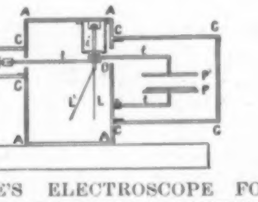


FIG. 2.—CURIE'S ELECTROSCOPE FOR THE STUDY OF RADIO-ACTIVITY.

the uranium salts upon it in a drawer, where it remained for several days on account of continuance of the cloudy weather. It then occurred to him to develop the plate; and much to his surprise he found a well-defined impression upon the plate, and this caused without any effect of phosphorescence due to exposure to sunlight. This led to his discovery and investigation of the remarkable radiations which have since been known by his name.§

I have here some samples of the first substances employed by Becquerel, consisting of double sulphate of uranium and potassium and double sulphate of uranium and ammonium, for which I am indebted to the courtesy of Dr. C. F. Chandler, of Columbia University.

Peligot in 1840 succeeded in isolating metallic uranium from the chloride. Well known forms of it are also uranium arsenate, uranium carbonate, uranium niobate, uranium phosphate, uranium silicate, and uranium sulphate. Uranium was first discovered in 1789 by the German chemist Klaproth, he naming it after the planet Uranus. I have here various forms of this uranium and also some metallic uranium prepared in the electric furnace by Moissan, which is more powerful than any other form of uranium.

Uranium, although widely distributed, is never found in large amounts, and forms several minerals. The commonest of these is "uraninite," commonly known as "pitchblende," which is a compound oxide containing 81½ per cent of uranium, 4 per cent of lead and ½ per cent of iron with oxygen and water, or sometimes magnesia, manganese or silica.

The pitchblende which contains the largest percentage of radioactive material, which has thus far been discovered, is the Bohemian pitchblende. It is also found in Saxony in small pockets, and a distinct vein

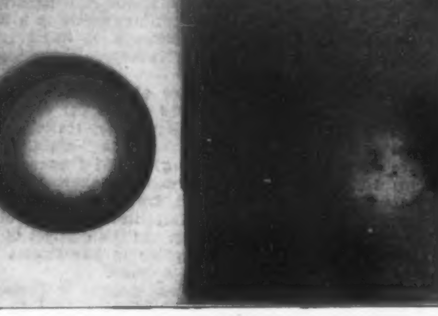


FIG. 3.—RADIOGRAPH MADE BY RADIUM OF A DISK FOR TESTING RADIO-ACTIVITY, A BLOCK OF ROCK SALT AND A LUMP OF PITCHBLENDE.

of it has been found in Cornwall, England. Prof. Curie informed the writer that he had secured some excellent radioactive pitchblende from the United States (Colorado).

The ore as mined in Cornwall yields 18 per cent to 20 per cent of the metal, this being the most important source, and this is usually put on the market in the form of uranium sesqui-oxide, and is largely used for giving porcelains a velvety black when heated in the annealing fire, and to some extent for imparting a greenish yellow fluorescence to glass. It has also been suggested to utilize it on account of its high resistance in connection with incandescent lighting.

Following the original discovery of the Becquerel radiations in 1896, came the discovery in 1898 of "Polonium," by Prof. Pierre Curie and Mme. Sklodowski Curie, who in investigating Becquerel radiations from uranium found some samples of pitchblende, from which the uranium is extracted, which was much more powerful than any uranium they had found, being four times the radioactivity of metallic uranium. Concluding naturally that the Becquerel radiations were due to some unknown substance in the pitchblende they commenced a most painstaking search for it, and discovered a substance associated with bismuth, which it resembled very much in its chemical char-

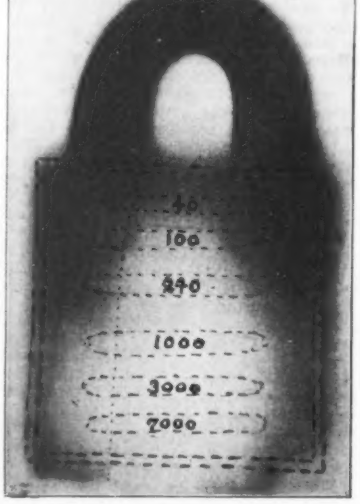


FIG. 4.—RADIOGRAPH SHOWING DEGREES OF PENETRATION OF LEAD AND STEEL BY TUBES OF RADIUM OF DIFFERENT RADIO-ACTIVITIES.

acteristics, to which Mme. Curie gave the name "Polonium," after her native land, Poland.

I have here perhaps the only sample in this country at present of metallic polonium, which in color resembles somewhat the particles of nickel; and here also is some sub-nitrate of polonium.

The two tubes which I have here to-night are of the sub-nitrate and metallic form, and possess a radioactivity of only about 300. The sub-nitrate form is a white powder, and the metallic, as said, resembles in appearance particles of nickel.

Polonium is precipitated by hydrogen sulphide.

Polonium apparently loses its power much more rapidly than radium; and the Curies have not been able to prepare any in which the rays have been deviable, although Giesel has prepared a form possessing both deviable and non-deviable rays. And Elster states that when polonium is placed in a vacuum, the rays may be deviated by a magnet to a greater extent than those of radium.

Polonium passes more rays through aluminium than do the rays from uranium; but Crookes has shown that they do not penetrate glass, as in the case of radium, and they are readily absorbed by minerals, and readily cut off by thin paper. They are readily absorbed by quartz, fluoride and mica, whereas these substances are freely penetrated by both radium and uranium.

In the same year in which polonium was discovered, those remarkable investigators, M. and Mme. Curie and M. Bemont, succeeded in isolating a second substance found in pitchblende, which was associated with barium and possessed many of the chemical and other characteristics of that substance, and to this they gave the name "Radium." Of this we shall treat later.

In 1899 was discovered the third substance in pitchblende, which possessed the chemical and other characteristics of thorium with which it was associated,

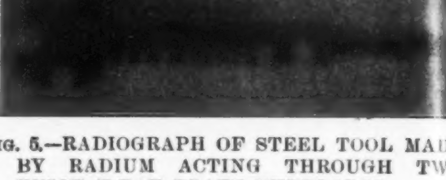


FIG. 5.—RADIOGRAPH OF STEEL TOOL MADE BY RADIUM ACTING THROUGH TWO THICK X-RAY PLATE ENVELOPES.

and to this Debierne gave the name "Actinium." It is precipitated by ammonium sulph-hydrate. Crookes states that actinium is identical with uranium, the substance which he had isolated from uranium and to which he gave the name "uranium X."

Of the three substances to which I have referred, radium is by far the most important and is of extraordinary interest. It is doubtful whether any substance has been discovered in the history of the world of such stupendous interest and importance and possessing such puzzling characteristics as radium, which seems so at variance with well-established scientific theories as to the constitution of matter.

My friend, Mr. R. R. Bowker, whom I met in Paris last fall, told the writer that he had shortly before that been dining seated between Lord Kelvin and Prof. Becquerel, and that Lord Kelvin had turned to him and said, that the discovery of Becquerel radiations had placed the first question mark against the principle of the conservation of energy which had been placed against it since that principle was enunciated.

Within the past month great interest has been attracted by the statement made by Profs. Curie and Laborde that radium maintains its own temperature at 1.5 Centigrade above its surroundings, this being equivalent to stating that half a pound of radium salt would evolve in one hour sufficient heat to equal that caused by the burning of one-third of a cubic foot of hydrogen gas; and that the heat evolved from pure radium salt is sufficient to melt more than its own weight of ice every hour; this evolution of heat going on constantly for indefinite periods and leaving the radium at the end of months of activity as potent as it was at the beginning. The problem therefore confronts the world of solving how radium can constantly throw off heat without combustion or without chemical change, as Prof. Curie says it does.

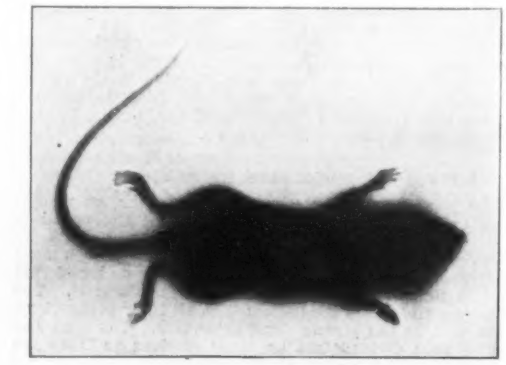


FIG. 6.—RADIOGRAPH OF A MOUSE MADE BY RADIUM IN TWENTY-FOUR HOURS.

Someone has remarked that for years we have been extracting uranium oxides, and pouring down the waste pipes and into dust bins the more interesting and precious radioactive substances.

Although radium, polonium, and actinium have been termed new elements, in the case of polonium and actinium, they have as yet not been found in sufficiently pure state and in sufficient quantity to give a spectrum, and to prove conclusively that they are new elements. Prof. Curie has, however, stated emphatically that there is now no doubt of radium being a new element.

The tiny brown bulb which I hold in my hand is the duplicate of the one which Prof. Curie showed me at his laboratory last fall, which contained the only sample of chemically pure radium in the world, this being between two and three one-hundredths of a gramme; and it was the spectrum of that sample, showing only the lines characteristic of radium, as tested by Demarçay, which demonstrated it to be a new element. And with this sample, also, the atomic weight for radium of 225 was determined. The

* A Lecture delivered before a joint meeting of the American Institute of Electrical Engineers and American Chemical Society, New York, April 17, 1903. The author of this paper has endeavored to exemplify certain fundamental principles connected with the phenomena upon which he has treated; and in considering these subjects, all of which may be said to be on the borderland of science, to bring out by means of experiments and illustrations which accompany the paper, the practical and commercial side.

† Comptes Rendus, February 10, 1896. Vol. cxxii., p. 312.

‡ Ibid., cxxii., p. 386.

§ Comptes Rendus, February 24, 1896. Vol. cxxii., p. 420.

atomic weight of the barium heretofore always associated with radium, but which in this sample had been eliminated, is but 157.

In answer to my inquiry as to its value, Prof. Curie said that 100,000 francs ($20,000) could not purchase this tiny sample.

I was enabled through the courtesy of Prof. Curie to secure from the Societé Centrale des Produits Chimiques of Paris, some nine different preparations of radium and two of polonium, which I have here for your consideration. I was unable to secure any actinium; in fact, but a trace of this substance has thus far been secured.

If the lights are extinguished, and you will sit for a few moments in the dark, I will pass these tubes about the room that you may observe the bright light given off by certain of them. These samples which I have range from forty times the radio-activity of uranium (which is taken as a standard), up to 7,000.

The laboratory, where these substances are prepared, is under the control of Prof. Curie; and up to recent date, all radium of higher radio-activity than 7,000 has been retained for the experiments of M. and Mme. Curie and their associates; but I received a letter recently from the Societé Centrale, in which I was informed that they will shortly put upon the market a preparation of radium, chemically pure or nearly so, at a cost of 30,000 francs ($6,000) per gramme or $2,721,555.90 per pound.

Radium, while it has been spoken of as a metal, has never been secured in a metallic form, the usual form being as a chloride or bromide.

Prof. Curie told the writer that the result of all the work done in Germany and France in the past three years had only resulted in the securing of about one pound of radium; this including all grades or qualities. Prof. J. J. Thomson says there is far more gold in sea water than there is radium, polonium and actinium in pitchblende.

Prof. Curie took this ring which I have on my hand, which contains a small diamond, into his dark-room and holding near it a small pill box containing about a gramme of radium, caused the stone to phosphoresce most beautifully. It was as if a lighted candle had been brought near to it. Prof. Curie remarked that this showed that the stone was a genuine diamond; and if it had been paste there would have been no effect produced, and that radium therefore constituted an excellent means for testing the genuineness of diamonds.

Practically all the radium which has thus far reached this country has been the German radium, and Prof. Curie informs me that he has tested all of their productions, and he has found none of them to exceed a radioactivity of 300.

De Haen of Seeze near Hanover, Germany, and Giesel, of Brunswick, have manufactured radium, and very recently the manufacture has been taken up in England. De Haen recently informed the writer that the preparations he puts on the market cost ten and thirty shillings per gramme.

As indicative of the enormous difficulties to be encountered in procuring this wonderful substance, it is interesting to note that it takes 5,000 tons of uranium residues to produce a kilo (2.2 pounds) of radium; and the cost of handling these residues is $2,000 per ton. To secure the chemically pure radium is enormously expensive, and it would be impossible to do this by chemical analysis, therefore the far more sensitive electrical method is employed, and the Curies say that they can detect the presence of a radioactive substance by the means of such a minute quantity that it would require 5,000 times this amount to show at all in the spectroscope. And it is stated that this method of electrical analysis is thousands of times more sensitive than spectrum analysis and millions of times more sensitive than chemical analysis.

In Fig. 1 is shown the "electrometer" method with which the Curies have studied the radioactivity of different substances. It consists of two plates, *A* and *B*, on the latter of which is placed the radioactive substance to be tested. This makes the air a conductor of electricity between the two plates, and for measuring this degree of conductibility, the plate *B*

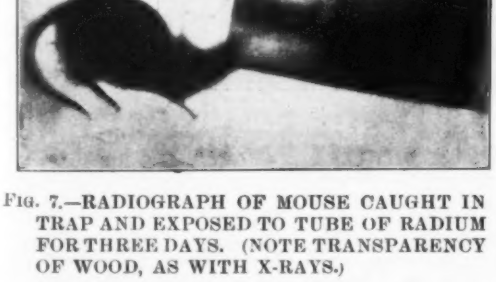


FIG. 7.—RADIOGRAPH OF MOUSE CAUGHT IN TRAP AND EXPOSED TO TUBE OF RADIUM FOR THREE DAYS. (NOTE TRANSPARENCY OF WOOD, AS WITH X-RAYS.)

is brought to a high potential by connecting it to one side of the storage battery *P*, the other side of which is connected to the ground. If the plate *A* is brought to the potential of the ground by the wire *C-D*, an electric current begins to flow between the two plates, *A* and *B*. The potential of plate *A* is shown by the electrometer *E*. If we cut this communication with the ground at *C*, the plate *A* becomes charged causing the electrometer to deviate. The speed deviation is proportionate to the intensity of the current and can serve for measuring it. But it is preferable to make this measurement in compensating the charge taken by plate *A*, so that the electrometer remains at zero. The charges which are extremely feeble can be compensated by means of Piezo-electric quartz, one armature of which is connected with the plate *A*, and the other armature grounded. The quartz plate is given a certain tension by weights placed on the plate *H*. This tension is gradually produced and gives a charge of a definite quantity of electricity which can be measured. The operation may be so regulated that there is a constant compensation between the quantity of electricity which passes through the condenser and that of the opposite sign furnished by the quartz. So we can measure in an absolute value the quantity of electricity passing through the condenser in a certain time.

Dolezalek has constructed an electrometer giving a deflection of 20,000 or more scale divisions for a potential difference of but one volt.

It is well known that the leaves of a gold or aluminium foil electroscope will hold their charge in dry air indefinitely; but the Becquerel rays are found to dissipate the charge by ionization of the air, and rendering the air a conductor of electricity (the electroscope may also be discharged by Röntgen rays, cathode rays, and ultraviolet light).

In Fig. 2 is shown a form of electroscope devised by the Curies for the study of radioactive substances.

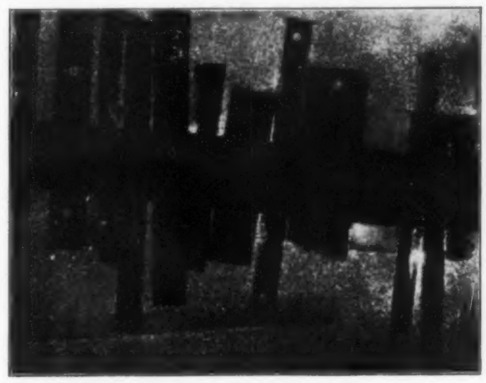


FIG. 8.—PHOTOGRAPH MADE BY PHOSPHORESCENT SULPHIDE OF CALCIUM OF VARIOUS METALS, CARBON, GLASS, MICA, CELLULOID, ETC., AND STRIP OF BLACK PAPER. (SEE FIG. 9.)

Referring to the diagram, it will be noted that the electroscope consists of a single movable sheet of gold or aluminium foil attached to a stationary sheet of copper *L*, being supported by the insulating piece *I*. The radioactive substance to be tested is placed on the lower of the disks *P* and *P'*, preferably on the removable plate. The radiations make the air a conductor between these two plates. The electroscope is charged by means of a stick of ebonite rubbed briskly and placed near the rod *B*. This deflects the sheet *L'* from the vertical and it so remains for a very long time. When radioactive substances are brought near it, the gold leaf is caused to lose its charge, and the leakage is observed by means of a stationary microscope shown in the left hand figure, which is provided with a micrometer. The time taken for the discharge of the electroscopes is taken by means of a chronometer or watch. By suitable lighting, the front edge of the foil may be made to appear as a very fine line, and its position noted with great precision.

By examining the diagram it will be noted that the upper condenser plate is connected with the metallic case. A detachable metal case is placed near the condenser plates and over the rod for charging the electroscope. Two of the sides of the case are of glass.

It is of paramount importance that the radioactive substance should be kept in a room distant from the electroscope.

At the present moment the clothes of every person in this room and all the walls of the room are radioactive by reason of the presence of the nine tubes of radium which I have here this evening.

Prof. Curie told the writer that it was often impossible for him to go near his instruments to make any measurements for hours, after being in the proximity of some radium, and those who have worked with this substance have found the greatest difficulty in keeping their tools and instruments and themselves free from the radioactivity imparted by the radium. The energy represented by radium is something enormous.

Elster and Geitel have shown that a fine wire of any metal, placed in the atmosphere and charged negatively from some source of current, say of 500 volts, causes the wire itself to become radioactive, and this radioactivity may be scraped off and will affect photograph plates, ionize the air, etc. It cannot, however, be washed off. It is stated that lightning rods and even the leaves of trees all become radioactive; and it has been shown that falling rain and snow are for a time quite powerfully radioactive; and after they have fallen, a wire negatively electrified in the atmosphere has only a small amount of radioactivity, apparently showing that the rain and snow have carried the radioactive particles in the atmosphere down to the ground.

McLennan has made experiments with the negatively charged wire in Montreal and subsequently at the foot of Niagara Falls; and has found the result about one-sixth as powerful in the latter place as in the former; and he has also shown that it was not necessary to electrify the wire used at Niagara Falls, as it received a sufficient charge from the electricity in the atmosphere.

McLennan found that rain caught in a vessel and immediately evaporated to dryness was found to impart radioactivity to the vessel in which it was evaporated.

Ordinary water when evaporated and rain water which has stood for several hours before being boiled down do not yield any radioactivity.

As an evidence of radioactivity imparted to another substance by radium, I have here some pieces of cardboard which constituted the box which held my samples of radium for several months. The box becoming injured, I broke it up, fortunately saving the pieces; and six days after the radium had been removed, I looked up the pieces and was surprised to find them brightly luminous in the dark. Subsequently I tried their effect on a photograph plate; but did not succeed in getting any impression. Three weeks later it occurred to me to try and stimulate the radioactivity of the cardboard, which had not been near radium for over a month, by burning magnesium wire, when I found I could make the cardboard brighter than it had been in the first place. I have also stimulated the radioactivity by sparks from a coil, especially when producing ultraviolet rays, by using a condenser bridged across the secondary and employing pure iron electrodes. I tried the burning magnesium with various samples of cardboard which had not been exposed to the radium, and there was no phosphorescence. It has already been stated that various substances which become radioactive retain that property for a short time only, and it is interesting to note its retention for such a long period of time and to note this ability to stimulate and make visible the imparted radioactivity.

This experiment suggests the discovery made by Prof. E. Wiedemann that a mixture of sulphide of calcium with a little sulphate of manganese is not altered when exposed to cathode rays; but some time after its exposure it bursts into a vivid greenish glow when slightly heated; and to this phenomenon he has given the name "thermo-luminescence."

Prof. S. P. Thompson also showed that fluorspar which by prolonged heating has lost its luminescing power, regains the power of thermo-luminescence when exposed to Röntgen rays when reheated.

Prof. Trowbridge also finds that this restoration is also affected by exposure to the electric glow discharge, but not by exposure to ultraviolet light.

It is also stated that an object coated with calcium sulphide and exposed to the sunlight will phosphoresce about ten hours; and even after it has lost luminosity, it can be caused to again give light by heating first by the hand, then over a water bath, and finally on a hot stove.

McLennan has found a very large number of salts are brought into a condition by cathode rays, in which warming makes them radioactive for a short time, the supply of negatively charged particles discharged from the surface coming to an end.

Prof. Rutherford of Montreal, who has given a great deal of attention to radioactive substances, particularly to investigations into thorium, which next to radium is the most radioactive substance yet discovered, has found by electrifying a wire negatively with a current of 500 volts connecting the positive pole to the ground, and by connecting a sample of thorium to the earth, that the thorium particles were attracted to the negatively charged wire, producing a greater radio-activity than he had ever found in any thorium preparation which he had made.

I have here a sample of oxide of thorium which is between 98 per cent and 99 per cent purity. From this substance Prof. Rutherford has isolated a substance which he calls "ThX;" and extraordinary as it may seem, it has been found after separation of the active constituents represented by the ThX from the thorium, that the ThX loses its radio-activity, and this is taken up by the thorium in exactly the amount which the other loses.

Sir William Crookes has also separated a non-uranium residue from uranium, leaving the latter without radioactivity. While the whole of the radioactivity has been concentrated in the residue to which the name UrX was given, Crookes claims that actinium is but another name for his UrX.

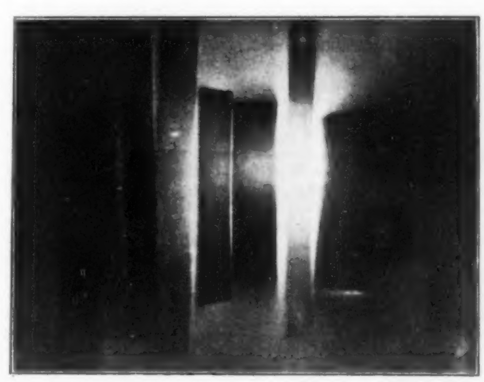


FIG. 9.—RADIOGRAPH MADE BY RADIUM OF SAME SUBSTANCES AS IN FIG. 8. NOTE BLACK PAPER IS TRANSPARENT, AS ARE CERTAIN OF THE OTHER SUBSTANCES.

The only case of radioactivity induced by cathode rays in a neutral substance has been that of bismuth, discovered by Villari.

Prof. Curie has discovered that radioactive gas emanates from radium, and Rutherford has discovered the gaseous emanations from thorium, the radioactivity of which was discovered by Schmidt. Messrs. Rutherford and Soddy have investigated extensively these emanations, and they have succeeded in condensing them at the temperature of liquid air. A preliminary account appears in the Proceedings of the Chemical Society of London for December, and Prof. Rutherford writes me that the full paper will shortly appear in the Philosophical Magazine; and he states furthermore that in his opinion this proves beyond doubt the gaseous nature of the emanations.

The serious physiological effects of radium are well known, and Messrs. Giesel, Becquerel, the Curies and

others, have given important evidence thereof. As stated in the appendix of a paper read by the writer at the 159th meeting of the Institute on January 3, 1902, dealing with the subject of radio-activity, Prof. Curie said that he would not care to trust himself in a room with a kilo of pure radium, as it would burn all the skin off his body, destroy his eyesight and probably kill him. The writer felt the effects for weeks of a slight burn from inadvertently carrying a wooden box containing eight tiny sealed glass tubes of radium under his arm for several hours.

Mr. W. E. Hidden has called my attention to some phenomena which he has observed in a mine in Barringer's Hill, Llano County, Texas, which mine contains yttrium, thorium, and uranium. Pockets of ore have been found, ranging from a few ounces up to a capacity of 70 kilos, which were the nuclei or focal points of rigid lines radiating in every possible direction. These lines penetrating great masses of quartz and orthoclase feldspar, and gigantic pegmatyt, to a distance often of several feet, in some cases of from five to eight feet, he has observed that these radial lines were fissures and bore no relation to the natural cleavage or the crystalline form of the huge rock masses in which they existed. Easy parting took place along these radial lines, making the ore quickly available.

Eighteen years ago, while in Italy, I visited the aquarium in Naples, which is probably the finest in the world; and while there was enabled to test the shocking abilities of the Electric Ray, or "Torpedo Galvani," and was astonished at the tremendous shock which I received; and in this connection, it is interesting to call attention to the fact that there are fifty or more fishes which are known to possess this property of giving powerful shocks; the "Gymnotus" or Electric Eel, and the "Torpedo Galvani" or Electric Ray being the best known of these.

It will be recollected that Faraday drew a powerful spark from a Gymnotus at the Polytechnicum, London, and he estimated the shock to be equivalent to that given by a battery of Leyden jars of 3,500 square inches of surface. And many writers have spoken of the ability of these electric fishes to give powerful shock for a long period of time. D'Arsonval has caused them to light incandescent lamps and they have been known to magnetize needles and decompose water by the electricity they produce. These fishes doubtless use this faculty as a means of defense and also for procuring food. My object in mentioning this is to state that last fall I again visited Naples, and thinking that perhaps an electric torpedo was on exhibition, it occurred to me to take with me some half dozen tubes of radium which I had in my bag, and see whether the radium had any effect upon the power of the fish to give powerful shocks. The fish, as at the time of my previous visit, was lying in a shallow wooden box containing wet sand and a small amount of water. By taking hold of the side of the fish and pressing with the thumb on one side and the fingers on the other, or by either pinching or tapping the fish, the cells with which the fish was equipped discharged themselves and gave a shock sufficient to twist one's arm very badly. After the members of our party had each received a shock, and as soon as a few persons present had gone away, I laid the six tubes of radium on the fish (which is shaped very much like a flounder), leaving them there for about twenty minutes. I then replaced the tubes in the box, and taking hold of the fish tried for fifteen minutes to get it to give me a shock by tapping or pinching in the same manner as previously done when the fish gave off shocks, and without receiving the slightest shock. Now, I am prepared to admit that the fish was "entirely out of shocks"; still, it is well known that these fishes will continue to give out shocks for a very long period of time, one authority reporting 360 shocks in seven minutes' time; but after exposing the fish to radium, I could get absolutely no manifestation; and in this connection, it is to be remembered that the physiological effects of radium, such as burning, destroying microbic life, producing the sensation of light when a tube is held against the closed eye or temples (which is doubtless largely due to the phosphorescence of the pupil of the eye, but which may also affect the nerve centers), and also the electrical effects, where charged bodies are caused to give off their charge by the ionization of the air; and one must also remember the very numerous chemical effects and the destruction of the germinating power of seeds, the changing of oxygen into ozone, and various other phenomena of radium which would lead one to wonder whether the radium did not affect the ability of the fish to give off electric shocks.

The experiment is of some interest, and may be perhaps repeated by others who have better facilities than I to continue the investigation. I have sometimes wondered how that fish was getting along in Naples; though I believe the waters of the Mediterranean abound in them.

It is Mr. Hidden's theory that, as these lines directed to ores rich in uranium and thorium, both well known sources of radium, etc., the phenomenon is due to an electric or other effect of radio-activity; it being untenable, he believes, to explain this phenomenon on the basis of expansion or contraction.

The slide which I will show on the screen shows clearly a pocket of ore with the lines radiating therefrom in all directions.

The work of Rutherford, the Curies, Becquerel and others has demonstrated that there are three entirely distinct types of rays emanating from radium (Rutherford having first pointed out that uranium possessed two separate types of rays, "α" and "β," the former easily absorbed even by gases, while the latter are very penetrating and but little absorbed by gas). Those which constitute by far the most important class are the "α" rays. They constitute the major portion of the rays, and are those which produce the greatest portion of the ionization of the gas, which has been observed under experimental conditions.

These "α" rays possess in common certain characteristics of Röntgen rays, and by many have been thought to be Röntgen rays. I shall call your attention to certain effects which are identical with those produced by Röntgen or X-rays. They have been considered absolutely non-deviable, as X-rays have been held to be.

Rutherford has, however, recently shown that in a very powerful magnetic field he could deflect about 30 per cent of the rays, and in experiments now being conducted with a strong electric field, he has been able to deflect about 45 per cent of the "α" rays. The "α" rays are readily absorbed, and a thin screen of metal will serve to cut off the greater portion of them.

In this connection I would state that Mr. Tesla informed the writer recently of an experiment he had made in which he had succeeded in deflecting the X-rays themselves, and M. Blondelot has recently claimed as the result of his experiments that X-rays are susceptible of polarization. If this is so, it is argued they may be shown to be ordinary light waves of extremely short wave length.

The "β" rays are much more penetrative and much longer, and in every particular correspond to the characteristics of cathode rays. They are readily deflected by a magnet. They discharge electrified bodies by ionization of the air, affect photograph plates, etc.

M. Villard, in 1899, proved that the cathode rays are negatively electrified corpuscles or fragments of atomic hydrogen, and these corpuscles, as they were named by J. J. Thomson, which he has shown to be one one-thousandth of the mass of the hydrogen atom, are projected from the cathode at a speed approximating 70,000 miles per second.

Strutt and Crookes have suggested that the "α" rays consist of positively electrified particles, and this view Rutherford supports, calling attention to the fact that they possess characteristics similar to the "Canal Strahlen" of Goldstein. These Goldstein rays have been shown by Wien to be positively charged particles, moving at high velocities.

Rutherford, as a result of his most recent observations, considers that the "α" rays move at much higher velocity than the Goldstein rays; and he estimates that the energy of the "α" rays is a thousand times greater than that of the "β" rays.

Rutherford says all the radioactive substances, including polonium, as well as excited bodies and the emanations, give out "α" rays.

The "γ" rays are the rays possessing the greatest penetrative effect. They will excite or produce radio-activity through the air at a distance of three or four feet or more.

Some recent experiments made by Rutherford show the relative penetration of the three classes of rays through aluminium sheets of varying thicknesses, before a loss is observed of half of the intensity, and this shows for the

"α" rays a thickness of aluminium of .0005 cm.
"β" rays a thickness of aluminium of .05 cm.
"γ" rays a thickness of aluminium of 8 cm.

Mr. Rutherford, who has conducted most painstaking investigations into the penetrative character of the radiations from uranium, radium, thorium, etc., recently wrote the author in answer to some questions on the subject, that he had found that the radium rays were reduced to half value after passing through 1 cm. of lead, 1 inch of iron and about 8 inches of water, the radiation being reduced to about 1 per cent of its original value, after passing through 7 cm. of lead, 7 inches of iron and 56 inches of water.

Prof. Curie states that half of this induced radioactivity, when exposed to the air, is lost in certain substances in half an hour; but in a closed vessel, where the air has been made radioactive, however, this radioactivity has not lost half of its strength even after four days' time.

It is desirable to keep radium free from moisture, preferably in sealed glass tubes. It readily takes up moisture, and then soon loses its luminosity, which may, however, be regained by dissolving and precipitating the substance and thoroughly drying it. The luminosity may also be considerably heightened by subjecting the radium to high temperatures.

Polonium like uranium does not possess the power of exciting radioactivity, as it does not give off any emanations; whereas, in the case of radium and thorium, there is an actual emanation, producing radioactivity in surrounding objects by the deposit of radioactive matter.

When one considers the remarkable effects produced by radium it would almost seem that it is matter tearing itself into tiny pieces, and projecting these infinitesimally small particles through all matter at a speed from half to even the full speed of light, and rendering all substances about it radioactive, and still without appreciable weight lost in the original substance; and without disparagement of the accepted wave theory of light, one naturally "harks back" to Newton's corpuscular theory of light.

While various theories have been advanced to account for the phenomena of radium, there remain many things which have not been satisfactorily accounted for; and perhaps the subject which has been most widely discussed is the loss in weight of radioactive substances.

At the British Association meeting last summer, Prof. J. J. Thomson is reported to have stated that if a square centimeter of surface were covered with pure radium, it would only lose in weight one thousandth of a milligramme in a million years. This is in accordance with the previous statements made by Becquerel.

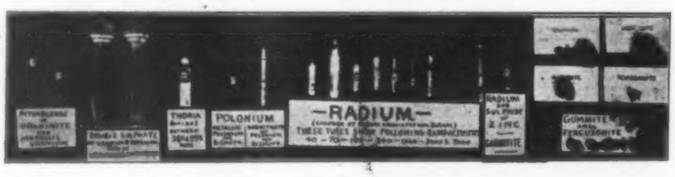
Later in the year, A. Heydweiller, of the Royal University, Munster, Germany, stated that he had been testing a sample of De Haen's preparation of radium, and found that it lost in weight two one-hundredths of a milligramme per day for fifty days, and a whole milligramme in that period. (Phys. Zeit., Oct. 15, 1902.)

The great discrepancy in the statements on this important subject, led the writer to enter into correspondence with Profs. J. J. Thomson, Henri Becquerel, Lord Kelvin, Sir William Crookes, P. Curie and A. Heydweiller.

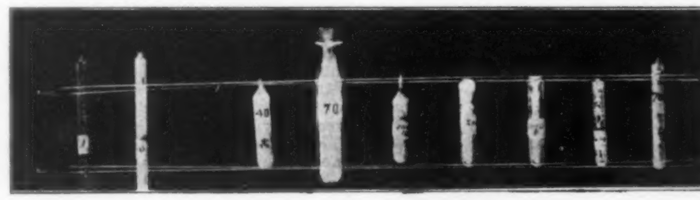
Prof. Thomson was inclined to believe that from the magnitude of loss found by Heydweiller, it must be due to some secondary effect, and he stated that he could not speak with certainty without a greater knowledge of the details of the experiments. As accounting for the results he, however, drew attention to the well-known coloration of glass by radium, by remarking, "One point, however, that ought to be attended to in these experiments is the effect of the radiation from radium on glass. Glass, as is well known, gets deeply colored when in contact with radium. It seems to me possible that the glass might be charged right through. If this were the case, it is possible that reactions might occur between the glass and the air, producing volatile substances and a loss of weight. I only throw this out with hesitation, for as I said before, I am not familiar with the details of the experiments."

Prof. Becquerel informed the writer that he knew nothing reliable regarding the experiments of Heydweiller, and called attention to his original paper on this subject which appeared in the Comptes Rendus of March 26, 1900, adding, "I believe I am the first to have published an estimate in this way which could only result from my own experiments. The loss of one milligramme per square centimeter requires one thousand million years. This statement refers only to the part of the deviable portion of the radiation to which measurements were applied; but this is only a part of the total loss. The deviable radiations comprise rays ranging from 10^9 and 3.10^{10} cm. Besides, there is also all the non-deviable portion, either penetrating or absorbing, which corresponds to a notable loss of energy; and in addition, if the emanation is of material importance, which seems quite probable, the loss on this account would be a thousand times greater. These estimates are but theoretical, for it is probable that at least a portion of the mass calculated or estimated as material is apparent and corresponds to the effects of induction."

In response to an expression of view from Sir William Crookes on a theory to satisfactorily account for the phenomena of radioactive substances, he wrote as follows: "You will find them fully given in my address to the British Association at their Bristol meeting in 1898. I have not seen any special reason to alter the views there propounded"; and in writing on the subject of Heydweiller's experiments, Prof. Crookes says, "I do not think the experiments of Heydweiller have been corroborated by other observers; and there are many sources of error in his experiment which I should like to see discussed before giving credence to it. Personally, I find no loss of weight in a rich sample of radium compound during continuous weighings extending over many months. I



VARIOUS FORMS OF RADIUM, POLONIUM, THORIUM AND URANIUM AND CERTAIN MINERALS FROM WHICH THESE RADIOACTIVE SUBSTANCES ARE EXTRACTED.



POLONIUM.
Metallic Polonium and Bismuth. Subnitrate of Polonium and Bismuth.

RADIUM.
(Chloride of Radium associated with Barium.) These tubes show the following radio-activities 40, 70, 100, 240, 1,000, 3,000, 7,000.

POLONIUM AND RADIUM.

should be inclined to agree with Becquerel and J. J. Thomson."

Lord Kelvin wrote that he was sorry not to have been able to make any experiments on radioactive substances which could allow him to offer any opinion that would be helpful on the subject, and added, "What you tell me regarding radium and your correspondence with Prof. J. J. Thomson is very interesting."

As regards the published statements of Prof. Heydweiller's experiments, the writer can state that he is reliably informed that a mishap occurred during his experiments which resulted in one of the tubes becoming cracked, which was not observed until later; and that this practically nullified the results published; and, in fact, they have not been confirmed by subsequent tests; but, on the other hand, they tend to corroborate the experiments of Becquerel and the statements made by himself, Sir William Crookes, J. J. Thomson, and others. The writer is also informed that Prof. Heydweiller is continuing further experiments, the results of which will doubtless be published when his investigations are complete.

As bearing upon the coloration of glass already referred to, I hold in my hand a flask which I secured at the laboratory in Paris, which has contained radium, and has been most beautifully colored a deep violet. I also have several tubes in which radium has been kept, which are similarly colored, and in this connection I would call attention to the fact that X-ray tubes which have been in use for a considerable time become similarly colored, forming another link between the Röntgen rays and radium rays.

I also have here a tiny bulb of glass which is colored a deep brown. I have seen only one other piece of glass colored in this way, this being due to the difference in the chemical constituents of the glass (though in some cases the glass subsequently turns a violet color). This is a duplicate of the tiny tube which Prof. Curie showed the writer, which contained between two and three one-hundredths of a gramme of chemically pure radium.

It is interesting to note that the Becquerel rays induce activity which persists, whereas that excited by Röntgen rays ceases immediately on the removal of the rays.

As illustrating the X-ray character of radium rays I would call your attention to Fig. 3, in the center of which is shown a block of rock salt. The original sample was about one inch thick, and was so transparent that a person's features might be seen through it. The rock salt is not only transparent to ordinary light, but also to ultraviolet light, whereas it is very opaque to X-rays.

The illustration referred to was made by placing the rock salt on a photograph plate with the radium some five inches above it.

To the right of the rock salt is shown a piece of uraninite (pitchblende), from which radium is extracted; and you will note that not only has the mineral been photographed by the radium above it, but the radium has acted on the radioactive constituents of the pitchblende and caused this to affect the plate.

The disk shown at the left of the cut is one made in Paris for the examination of radioactive substances. I have one of these here, and it consists of a rim of brass, inclosing a brass washer with a glass disk at the center. The opposite face is covered with aluminium foil, and between the aluminium and the glass is placed some radium of 1,000 radioactivity. Substances which it is desired to examine are laid on this disk. It is, however, a rather crude piece of apparatus; but in the cut shown not only has the disk been photographed by the radium five inches above it, but the radium inside of the disk has penetrated through the aluminium and fogged the plate.

In Fig. 4 is shown another illustration of the penetrative character of the rays, it being a thick lead box containing six tubes of radium, ranging from a radioactivity of 40 to 7,000; this box being laid upon a large steel magnet three-eighths of an inch thick. You will note the degree of penetration of both the lead and the steel varies according to the radioactivity of the radium in the various tubes. The exposure was made in twenty-two hours.

Fig. 5 illustrates the penetration of the rays through black paper, the steel tool shown having been laid on the plate covered with two thicknesses of heavy paper, such as used for wrapping X-ray plates; a single sheet of which is entirely impervious to light. The exposure was made in twenty-four hours.

Fig. 6 shows a mouse which was radiographed in twenty-four hours by laying it directly on a plate, which was, as in the case of other experiments, placed in the bottom of a trunk, the trays being replaced and the trunk wrapped in three thick rugs, and kept in a dark room for twenty-four hours.

The radiograph of the mouse shown in Fig. 7 represents a mouse caught on another occasion, in which I placed the mouse, trap, and all on the plate, leaving it there for three days. The trap was an ordinary 6 cent trap; and it will be noted that the metal parts of the trap are shown opaque, whereas the portion of the wood nearest to the radium is shown absolutely transparent, as if it had been exposed to X-rays. In the original photograph the mouse is also shown somewhat transparent, indicating slightly the bones.

I also show you upon the screen a slide which I have made of a radiograph of a human hand. This was exposed for seven days, and bears the resemblance to an X-ray picture which has been over-exposed. In making a faint print of this, a slight trace of the bones is shown. This is, perhaps, the first picture made of the human hand by means of radium; and it would not have been possible, of course, to have exposed a living person to these rays for even a small percentage of this length of time. Perhaps subsequent experiments will bring out much more strongly the bone structure.

As X-rays will excite phosphorescence in many substances, one would naturally wonder whether there were any X-ray characteristics in phosphorescent substances.

An interesting experiment is shown in Figs. 8 and 9. In the former experiment, I have placed strips of various metals, such as brass, iron, copper, tin, lead, tin foil, aluminium, magnesium, etc., and strips of carbon, vulcanite, glass, mica, and celluloid. Across the middle of the plate I have placed a strip of thick black paper cut from an X-ray plate envelope. I then sprinkled over the entire plate by means of a sieve sulphide of calcium, which I had made brilliantly phosphorescent by exposure to burning magnesium ribbon. The only substances which allowed the light to pass through at all were the glass, mica, and celluloid, the other substances, including the paper, being very opaque, showing apparently only the presence of ordinary light rays. This plate was placed for twenty-four hours in a dark room.

In Fig. 9 are shown some substances similarly arranged, but exposed to a tiny tube of radium of 7,000 radioactivity, which was placed 3 inches above the plate and near the center. The exposure was made for twenty-five hours; and it will be noted that the strip of black paper has entirely disappeared, and the various substances underneath it have been penetrated to a greater or less degree; particularly, those nearest to the radium.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Industrial Census of Bohemia.—As a result of many years' agitation of the subject by commercial interests, the government of Austria-Hungary, early in 1902, made provision for an elaborate industrial census. This work in Bohemia was assigned to the official chambers of commerce, namely, at Prague, Reichenberg, Eger, Budweis, and Pilsen, each of which governs a specified territory. The work in the Reichenberg district has just been completed, at a cost of $21,518—1,040 enumerators having been employed. The full report is not yet available, but a summary of results has been given out by the president of the chamber. Aside from its statistical value, the summary discloses industrial conditions perhaps not generally appreciated. The territory embraces 3,120,131 acres and has a population slightly in excess of 2,006,000. When it is considered that Reichenberg, with a population of only 50,000, is the largest town, it is seen that the distribution of inhabitants throughout the district must be general. Within this area are scattered 116,257 independent manufacturing, commercial, trade, and productive concerns, employing 460,327 persons, exclusive of 105,867 employed in "home industry." To this latter class belong 15,544 engaged in various processes of glass finishing; 6,769 in wood, wood-carving, and wicker work; 69,211 in the textile trade; and 8,775 in the manufacture of dress ornaments and flowers. These "home" workers live in the little villages, which stretch almost contiguously along the banks of mountain streams, and in the wider valleys, and the women and girls, in great baskets slung on their backs, carry the raw and finished goods between home and factory over steep mountain paths, which in winter are covered with snow and ice. The factories themselves are widely scattered, compelled to seek water where it can be found in the mountains and valleys, with apparent disregard of transportation facilities. Thus, around an isolated factory will grow up a little village, the inhabitants of which, directly or indirectly, are dependent upon the work it furnishes, and whose children grow up with no other expectation than that of taking their parents' places as factory hands. This process develops families of specialists, whose method of life is primitive and whose very existence depends upon the prosperity of their particular factory, for the high altitude and the character of climate and soil make agriculture but a poor supplement, even most vegetable supplies being imported either from Germany or southern Bohemia.

Of the 116,257 industries and occupations, 74,548 are manufacturing concerns, 41,062 trade and professional, and 647 engaged in original production, such as mining, farming, etc. The following are the principal groups: Preparation of spinning material, 194 concerns; spinning and weaving wool and half wool, 363; spinning and weaving cotton, 1,206; linen mills, 483; hosiery factories, 598; refining of yarns, 639; manufactories of glass, glass stones, and clay products, 4,583; metal industries, 6,413; building concerns, 3,217; chemical and drug trade, 606; provision dealers, 10,859. In the textile division there are 1,925,136 spindles and 77,991 mechanical looms—in wool, 187,767 spindles; cotton, 1,456,880; flax, 262,593. Altogether, 5,712 manufacturing plants using power utilize but 216,177 horsepower, and of these 1,087 in the textile branch use 100,730 horse power. Engaged in these power concerns are 218,219 persons, of whom 78,199 are females. In the textile branch but 59,920 of 123,338 employes are males. Reichenberg, with its immediate suburbs, maintains its industrial supremacy with 7,882 manufacturing and trade concerns.—S. C. McFarland, Consul at Reichenberg.

Agricultural Lands in Cuba.—In reply to an inquiry relative to the advisability of investments in agricultural lands in Cuba,* Consul R. E. Holaday, of Santiago de Cuba, under date of April 15, 1903, writes:

Considerable quantities of land have already been bought by citizens of the United States and by companies organized and capitalized in the United States. Persons desiring to buy land should either make a personal investigation or be represented by some competent person, as there is much undesirable and unproductive land on the market. The soil of Cuba is adapted to the production of coffee, sugar, cacao, tobacco, corn, potatoes, vegetables, and tropical fruits of all varieties, but there are large areas that are nonarable. Coffee and cacao are raised principally in the mountainous regions. The cacao is cultivated in connection with the coffee plant, as the latter requires shade, which is furnished by the former, at the same time yielding a profitable crop. Cacao can also be profitably grown in the lower and richer districts. The rich river valleys and plains are devoted to the cultivation of sugar cane. There are large areas of land suitable for grazing, and the raising of cattle will unquestionably become one of the profitable industries in the near future. It must not be understood that all of the land in Cuba suitable for cultivation is being cultivated. There is much virgin land which the future development of the means of transportation will some day make very valuable. There are also many abandoned estates, which were destroyed during the wars in Cuba, the owners of which are either too impoverished to again establish and operate them or they do not desire again to undertake planting. There is no direct land tax. The owners of real property are taxed upon the income which the property yields. Public roads are well defined, but in bad condition. In the interior of the island they are mere trails and travel is almost wholly by horseback. The construction of the new trunk-line railroad, lately completed, extending from San Luis, in this province to Santa Clara, in the province of Santa Clara, thus establishing direct railroad communication—by connection with other lines—between this city and Havana, will be an important factor in the future development of large sections of the island which have heretofore been utilized only to a limited extent, on account of the lack of adequate and sufficiently rapid means of transporting the produce of the soil to the local markets and to the seaports for exportation. The climate is tropical and salubrious. No contagious or endemic diseases exist. With the observance of the ordinary rules of hygiene one should enjoy as good health here as he would under the same conditions in a temperate climate.

* The original letter has been sent the inquirer.

Silver and Plated Ware in Spain.—The following has been received from Consul R. M. Bartleman, of Valencia:

Special Consular Reports, Volume XXIII, on Silver and Plated Ware in Foreign Countries contains no reports from Spain. There is, however, a large demand for silver and plated goods in this country, not only in crosses, chalices, and other sacred vessels employed in church services and ornamentation, but also in plain and fancy tableware. Only one important factory of such goods exists in Spain—that of Don Emilio Meneses, at Madrid, founded in 1840, which supplies the greater part of the national wants.

The Spanish tariff on silver and plated ware is annexed. American silver and plated goods are superior in finish to those sold here, and I am of the opinion that United States manufacturers, after allowing for freight and tariff, could compete in price with the Spanish product on these markets.

The consulate at Madrid, where the Meneses factory is established, could give manufacturers more ample details as to particular lines of plated ware, processes and cost of manufacture, demand, discounts allowed to wholesale dealers, etc.

CUSTOMS TARIFF FOR THE PENINSULA AND BALEARIC ISLANDS.

Tariff number.	Articles.	Duty.				Mode of collection.
		Maximum tariff		Minimum tariff.		
		Pesetas.	Cents †	Pesetas.	Cents.†	
26	Silver in jewelry or plate, even set with pearls or precious stones,* per hectogramme (3.5 ounces).........	4.20	58.8	3.50	49	Net weight
27	Gold, silver, or platinum worked into other objects,* per hectogramme....	3.20	44.8	2.60	36.4	Do.
	Copper and its alloys (white metals).					
‡C. 82	The same metals and alloys, in gilt or silvered articles,§ per kilogramme (2.2 pounds)......	3.75	52.5	2.50	35	Do.

* In the classification of jewelry or ornaments will be included all small articles of luxury, valuable on account of workmanship and generally intended for the ornamentation of persons of both sexes. In clearing finished articles, including jewelry and articles of gold, silver, or platinum filled with mastic, a reasonable tare allowance shall be made for such mastic. Utensils for domestic use, articles for church use, and, generally, all larger objects used for the ornamentation of houses, are included in this number.

† Taking the market value of the peseta at 14 cents. It should be noted that the maximum rates of duty apply to United States goods.

‡ Certificate of origin.

§ To detect gilt articles, they will be rubbed with hot alcohol and afterward touched with one drop of nitric acid. If they are varnished only, the varnish will disappear with the alcohol, and the acid will produce its effect; if they are gilt, neither the alcohol nor the acid will produce any effect. Silvered articles will be filed until the metal underneath the superficial coating appears; moreover, if a portion of the plated metal be dissolved in nitric acid, the silver, should any exist, will be precipitated by adding hydrochloric acid, and a chloride of silver soluble in ammonia, with all the characteristics of this substance, will be formed.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECIPES.

In Estimating the amount of paint needed for a given surface, divide the number of square feet by 200. The result will be the number of liquid gallons required. Saltpeter solution washed over greasy spots will permit the paint taking hold.—Mining and Scientific Press.

Paste to Affix Labels to Tin.—W. A. Richmond recommends as a paste for affixing labels to tin, thick flour paste with the addition of tartaric acid. The paste is to be boiled until quite thick and the acid previously dissolved in a little water is added, the proportion being about 2 ounces to the pint of paste.—Bull. Pharm.

To Bleach Sponges.—

I. Soak the sponges in dilute hydrochloric acid for 12 hours, wash well with water to remove the lime, then immerse in a solution of 2 pounds of sodium hyposulphite in 12 pints of water, to which 2 pounds of hydrochloric acid have just been added. After being sufficiently bleached, remove the sponges, wash again, and dry.

II. Soak in dilute hydrochloric acid to remove the lime, then wash in water, and place for 10 minutes in a 2 per cent solution of potassium permanganate. The brown color on removal from this solution is due to the deposition of manganous oxide, and this may be removed by steeping for a few minutes in very dilute sulphuric acid. As soon as the sponges appear white, they are washed out in water to remove the acid.—Drug. Circ. and Chem. Gaz.

Repolishing Old Furniture.—Make a paste to fill cracks as follows:

Whiting, plaster of Paris, pumice stone, litharge, equal parts, Japan dryer, boiled linseed oil, turpentine, coloring matter of sufficient quantity.

Rub the solids intimately with a mixture of 1 part of the japan, 2 parts of the linseed oil, and 3 parts of turpentine, coloring to suit with Vandyke brown or sienna.

Lay the filling on with a brush, let it set for about 20 minutes, and then rub off clean except where it is to remain. In two or three days it will be hard enough to polish.

After the surface has been thus prepared, the application of a coat of first-class copal varnish is in order. It is recommended that the varnish be applied in a moderately warm room, as it is injured by becoming chilled in drying. To get the best results in varnishing, some skill and experience are required. The varnish must be kept in an evenly warm temperature, and put on neither too plentifully nor too gingerly.

After a satisfactorily smooth and regular surface has been obtained, the polishing proper may be done. This may be accomplished by manual labor and dexterity, or consist in the application of a very thin, even coat of a very fine transparent varnish.

If the hand-polishing method be preferred, it may be pursued by rubbing briskly and thoroughly with the following finishing polish:

Alcohol	8 ounces
Shellac	2 drachms
Gum benzoin	2 drachms
Best poppy oil	2 drachms

Dissolve the shellac and gum in the alcohol in a warm place, with frequent agitation, and, when cold, add the poppy oil.

This may be applied on the end of a cylindrical rubber made by tightly rolling a piece of flannel which has been torn, not cut, into strips four to six inches wide.

It should be borne in mind that the surface of the cabinet work of a piano is generally veneered, and this being so, necessitates the exercise of much skill and caution in polishing.—Drug. Circ. and Chem. Gaz.

New Chemical Products and Their Employment as Photographic Developers.—1. A solution of 126 grammes of pyrogallol in the necessary quantity of distilled water is added to 225 grammes of a 20 per cent solution of dimethylamine and the mixture allowed to repose sheltered from the air. After a little time the liquor heats spontaneously, and a precipitate with large prisms commences to separate within the mixture. When the reaction is completed the precipitate is still sheltered from the air and dried at low temperature. The additional combination thus produced is readily soluble in water, but soluble with difficulty in alcohol, and insoluble in ether. It melts at 163 deg. C.

The process is effected in a similar manner by employing other aliphatic or cyclic amines. Below are given the fusing points of a few products of these new combinations derived from pyrogallol: With trimethylamine, 160 deg. C.; with monomethylamine, 124 deg. C.; piperazine, 150 deg. C.; piperidine, 177 deg. C.; quinaline, 72 deg. C.; oxyquinoline, 112 deg. C.; triacetonamine, 98 deg. C.

2. 110 grammes of resorcin are dissolved in 300 cubic centimeters of ether, and into this solution are poured 200 cubic centimeters of a 22.5 per cent aqueous solution of dimethylamine. Then petroleum ether is added until the liquor begins to be clouded. In about twenty-four hours the new combination is precipitated in the form of prismatic crystals melting at 82 deg. C.

The product obtained from resorcin and quinoline melts at 75 deg. C.; that of resorcin and oxyquinoline melts at 95 deg. C.

These combinations, of which we have described the preparation, adapt themselves in an excellent way to employment as photographic developers; they develop rapidly without the addition of caustic alkali, but with the aid of alkaline sulphates. They produce a photographic image without fog and very distinct by making use of the following recipe:

Eight grammes of sodium sulphite are dissolved in 100 cubic centimeters of water, and in this solution is dissolved cold 1 gramme of the combination. The solution is precipitated by shaking the mixture. The developer is then ready for use.—From the French, in La Revue des Produits Chimiques.

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